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NATIONAL WATER RESEARCH INSTITUTE

WESTERN AND NORTHERN REGION,
AT THE FRESHWATER INSTITUTE, WINNIPEG

A STUDY OF PHOSPHATE CONTRIBUTION TO THE FISHING LAKES FROM THE SHORELINE COTTAGES IN THE QU'APPELLE BASIN

BY

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W.N.R.-PR-79-2.

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FOREWORD

This report was prepared under contract for the National Water Research Institute, Western and Northern Region, by the Saskatchewan Research Council. The principal investigator was Dr. G. Lakshman. The Scientific Authority for the contract was Dr. R. J. Allan, Chief, N.W.R.I.-W.N.R.

The report provides information on the local inputs of phosphorus to the Fishing Lakes of the Qu'Appelle River Basin.

The main local sources of phosphorus loading appear to be from the Fort Qu'Appelle sewage lagoons and by groundwater injection from the Hatfield Valley Aquafer. Cottages and minor septic tank operations in the valley do not appear to make significant contributions.

The loading from the Hatfield Valley Aquafer is highly speculative and considerable further work would be necessary to refine the estimates.

The loading from the Fort Qu'Appelle lagoons is small compared with the total load of phosphorus contributed to the Fishing Lakes chain by the Qu'Appelle River. However, much of the Qu'Appelle River load passes through the chain of lakes, whereas the input to Mission Lake immediately downstream from Fort Qu'Appelle may sediment in or be involved with algal biomass production in this lake.

R. J. Allan

March 29th. 1979

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ABSTRACT

A short-term study was undertaken during the summer of 1977 to evaluate the phosphate contribution due to septic effluents from cottages on The Fishing Lakes in the Qu'Appelle basin in Saskatchewan. Extensive information on the location of cottages, effluent disposal practices and the probable number of cottages with leaking septic tanks was collected during the initial phase of the study. Soil and water samples were taken from disposal sites and at two problem cottages to delineate the ability of soils to contain the pollutants within the seeping zone.

Data from producing wells tapping the deep aquifer zones are very scanty for estimating the contribution of phosphorus from the Hatfield Valley aquifer to the Qu'Appelle River system. However, a gross estimate of this input is given as 21,000 kg of PO_4-P, annually.

The disposal sites do not appear to contaminate either the deep aquifer or the lake waters but direct discharges or leaking septic tanks from cottages do pose a threat to the quality of well and lake waters. From this study and from a limited survey carried out by the provincial Department of Health it is estimated that the number of cottages with effluent problem ranges from about 2% to about 5% of the total number of cottages on Pasqua, Echo, Mission and Katepwa. This would amount to a maximum direct loading of 234 kg of phosphate-phosphorus into The Fishing Lakes.

Attention is drawn to the existence of several point sources such as parks, campgrounds, training and recreation centres which are not usually included while accounting for effluents from municipal or domestic sources. Soil leachate values for phosphorus from disposal sites are not distinguishable from the background values. Scarce data on deep aquifer wells do not provide a reliable estimate on the influx of phosphorus from groundwater.

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SUMMARY

There are several point and non-point sources of pollution in the Qu'Appelle basin which contribute phosphorus and other nutrients to the Qu'Appelle River affecting the recreation potential of The Fishing Lakes. Large growth rate in the number of cottages on Pasqua, Echo, Mission and Katepwa lakes has made it necessary to evaluate the effluent disposal practices and the threat to the lake water quality from either direct discharges of septic effluents or leaking septic tanks. Earlier studies conducted by various provincial and federal agencies (Ref. 1-13) in the area do not provide information on the significance or magnitude of phosphorus influx from cottages. The present study was, therefore, undertaken to fill the gap and provide data on cottage effluents, an important component in a comprehensive evaluation of water quality deterioration in the Qu'Appelle River. Due to the sensitive nature of the issue and a lack of co-ordinated data on cottage effluent disposal practices it was necessary to devote a considerable part of the project time to gathering this preliminary information. The duration, frequency and magnitude of field sampling were limited to a few chosen sites because of the budgetary restrictions.

As a normal practice the effluents from cottages are transported to disposal lagoons at Lebret, B-Say-Tah and Katepwa. Occasionally, they are also discharged on farm sites and seepage pits approved by the Department of Health. Soil and water samples were collected from the regular and major disposal sites, lakes, wells and test holes in the seepage zones of disposal lagoons and leaking septic tanks. Soil

leechates were analysed for total phosphates, inorganic phosphates and water soluble chlorides. Water samples were analysed for total phosphates, total organic carbon, water soluble chlorides, conductivity and pH. A total of 372 soil samples and 113 water samples were collected out of which 98 soil samples and 76 water samples were analysed. A procedure was developed using chlorides as tracers to determine the sorption of phosphates in soils. Two cottages, one on Pasqua and the other on Echo were selected for study as both were known to have leaking septic tanks. Seepage samples were taken for analysis from non-dry test holes to determine the movement and reduction of phosphate levels at various distances from the septic source. Water samples were also collected from lake waters in front of some selected cottages.

Results show that soils in the lagoon area effectively adsorb phosphates and the threat to the lake water quality is minimal. Sealing of sidewalls and bottom in the lagoons is an important factor which minimizes the transport of nutrients. However, the results from the sampling sites at the two cottage sites show that very little phosphates from the septic seepage is retained in the soil zone. The nature of the soil, moisture regime and the proximity to the lakes are some of the contributing factors to the contamination of lake waters, from problem cottages.

Our own inventory and a limited survey conducted by the Department of Health over the years indicate that the number of cottages with leakage problem is limited to about 2 to 6 percent of the total number. There are several other sources of effluents which do not

come under either the municipal or the industrial category. These are the parks, campgrounds, recreation and training centres which produce effluents that eventually end up in the lakes. Although the problem of leaking septic tanks and direct discharges is probably limited to a small percentage of the total population, it still poses a threat to the quality of water in the lakes as well as the wells in the shoreline properties. It is unlikely that effluents from the disposal lagoons at Lebret and B-Say-Tah would enter the deep groundwater sources. However, information from deep wells tapping the aquifer system in the valley is too limited to make definite predictions. A flow diagram showing the estimated magnitudes of various phosphorus pathways into The Fishing Lakes is given to indicate the relative significance of various sources.

INTRODUCTION

The Qu'Appelle River basin which spans about 20,000 square miles is one of the major river basins in Saskatchewan. It supports a population of approximately 280,000 in urban and rural centres and hundreds of livestock operations on the farmland. Qu'Appelle River passes through seven major lakes before reaching its confluence with the Assiniboine River in Manitoba. There are about ten major and numerous minor tributaries that contribute to the flow in the Qu'Appelle River. Because of its association with the local aquifer systems such as the pre-glacial Hatfield Valley aquifers and its large drainage area the river system has become an abundant source of surface water in Saskatchewan with an excellent recreation potential. However, the quality of water in the river is significantly affected by the quality of runoff through its major tributaries and the waste disposal practices in the rural and urban communities within the basin. Effluents from industrial, municipal and livestock operations are continually flushed through the system precipitating pollutants in the relatively stagnant lakes. In addition, depending upon the extent and magnitude of spring runoff non-point sources such as the agricultural lands and manure spreading areas also contribute nutrients to the river. Over the years, the hazard of pollution has steadily eroded the recreation and resource potential of the Qu'Appelle River system. There has been a concerted effort by the Qu'Appelle Implementation Office and the Family Farm Improvement Branch of the Department of Agriculture to change the existing land use practices through re-

location of feedlots and a comprehensive land management program. Although maintaining the quality of river flow at a reasonable level is the general concern, the deterioration of water quality in The Fishing Lakes such as Pasqua, Echo, Mission and Katepwa has drawn in public and scientific discussions. The effect of algal blooms on the fish populations and general recreation in these lakes has been quite obvious. The following is a list of major nutrient sources that enrich the lake waters, although the relative significance of their actual contribution has not been evaluated in many cases. The sources are

1) Municipal effluents from cities and villages after undergoing some or no initial treatment.

2) Industries.

3) Livestock feedlots within the basin.

4) Agricultural lands which produce nutrient-rich runoff from fertilized soil.

5) Groundwater influx from shallow and deep aquifers.

6) Septic tank discharges from the shoreline cottages

and 7) Direct precipitation.

The last source is included here because of the possibility that it could be significant on an annual basis. Recent measurements in other parts of Canada have shown that phosphorus contribution by precipitation (rainfall and snow) is not totally insignificant (Ref. 14).

Studies conducted by universities, provincial and federal agencies have looked into the contribution of pollutants from municipal sources

(Ref. 1-13). A joint research program between the Saskatchewan Research Council and the Family Farm Improvement Branch of the provincial Department of Agriculture has produced field data on the transport of nutrients from feedlot operations in the Pheasant Creek basin, a major tributary to the Qu'Appelle River (Ref. 15). Cullimore et al monitored the bacterial contamination in the vicinity of cottages on The Fishing Lakes, but the study was not aimed at quantifying the total input of phosphates from the cottages. (Ref. 7). Allan and Williams studied the sediment chemistry in The Fishing Lakes (Ref. 22) and noted that it reflected the local P-loading characteristics. The role played by the nitrogen-phosphorus ratio in the eutrophication of prairie lakes was studied by Allan and Kenney (Ref. 23).

The present study was initiated to estimate the quantities of phosphate transported from regional groundwater and from septic tanks into The Fishing Lakes and evaluate the relative significance of various influxes from such areas as the septic disposal sites, tile fields and seepage from leaky tanks. The objectives of the study were,

1) To survey the area to determine the extent of non-standard and unregulated disposal of septic tank effluents and estimate the quantities,

2) To collect and analyse soil and water samples representing the various methods of effluent disposal. The samples were to be taken from the surface runoff from lagoons and agricultural spreading areas and subsurface flow from leaking septic tanks,

3) To generate recommendations based on the field observations on the status of nutrient input from cottages into the Qu'Appelle lakes.

The main thrust of the study was to develop an overview of the pollution situation, within the budgetary constraints of the project. This report describes the field sites, data collected and the results obtained with recommendations for future work.

SCOPE OF THE STUDY - NATURE OF THE PROBLEM

Hundreds of cottages that have been developed around The Fishing Lakes produce nutrient rich effluent which, if not properly disposed, would be a threat to the quality of lake waters. Earlier studies have monitored the effect due to the large point sources such as the cities of REgina and Moose Jaw, and the lagoon discharges from rural communities. Although cottages do not produce large effluent volumes and most of them operate only part of the season, they still cause concern because of their close proximity to lakes and wells within their seepage field. At the beginning of the study it was soon realized that complete information on the location of cottages, nature of septic tanks and the total percentage of tanks that are serviced was totally unavailable either because it was not co-ordinated and collated at any one source because the relevant data had not been collected. In addition, the situation was quite sensitive in that no information could be easily obtained regarding the suspected number of leaking tanks without arousing the ire of the concerned parties. Since the magnitude of direct phosphate influx into the lakes from cottages depends upon the extent of septic leakage, it was necessary to devote a considerable part of the study to obtaining or estimating this information.

Apart from the wastes disposed into the Qu'Appelle River from major municipalities and non-point agricultural sources, there are many other point sources which are widely distributed in the basin and whose phosphate contribution is seasonal and undergoes attenuation

in the soil strata. These include the parks, campgrounds, church centres, fish hatchery and some recreation centres. Information obtained regarding the effluent disposal practices in these areas is summarized in Tables 1 and 2. Acquisition of cottage information was the most time consuming part of the entire study. Several provincial agencies, private contractors and numerous local residents were either interviewed or consulted to obtain the information. During this time it became evident that no government agency had all the relevant data pertaining to all The Fishing Lakes and most of the data that were available had not been updated. Tables 3A and 3B summarize the sources consulted for various information. Detailed lists of lots, cottages and disposal services are given in Appendix A. Most of the cottages on Pasqua, Echo, and Mission are new compared to the cottages on Katepwa. Septic effluent is stored in either tanks or vaults which are usually of 1000 to 1200 gallons capacity. They are normally inspected after installation by the local public health inspector. There are only two commercial septic services available in Fort Qu'Appelle, Lebret and B-Say-Tah areas. They are the Fort Septic Service and the Pantel Plumbing and Heating Ltd. and both operate from Fort Qu'Appelle.

Septic effluents are normally pumped from individual cottages and discharged into disposal lagoons approved by the Department of Public Health. In some cases, the effluents have been discharged on agricultural lands or seepage pits; these are relatively infrequent and undocumented. Until recently, the commercial services were allowed to discharge effluents into Fort Qu'Appelle's town lagoons.

Table 1

MAJOR SOURCES CONTRIBUTING PHOSPHORUS TO FISHING LAKES IN THE QU'APPELLE BASIN.

A. Pasqua Lake

	Source	Sewage Disposal System	Remarks
1)	Echo Valley Provincial Park	Two-cell lagoon	Lagoon SE of lake. Never discharged, High seepage loss.
2)	Luther's Point Church Camp	Septic tanks	NE of lake. Tanks not serviced by Pantel or Fort septic services.

B. Echo Lake

1)	Echo Valley Provincial Park (part)	Pumped to lagoon on Pasqua	West of lake.
2)	Fish Hatchery	i) Septic tanks for office, etc. ii) Process water discharged to lake	South of lake. Septic tanks services regularly.
3)	Camp Ta-Wa-Si (YMCA)	Old system used pits Presently installing new tanks with drop tube system	North of lakes.
4)	Evangelical Church Camp	10,000 gallon septic tank	North of lake. Regularly serviced.
5)	Echo Valley Centre (Centre of Arts)	Primary wastewater treatment system discharged to Echo lake.	North of lake.
6)	Prairie Christian Training centre	Septic tanks with tile fields or mounds	North of lake. Serviced annually some complaints four tile fields.

Table 1 (Con't)

	Source	Sewage Disposal System	Remarks
		B. Echo Lake (con't)	
7)	Echo Valley centre (Recreation centre) (DTRR)	Tanks	East of lake. Serviced regularly.
		C. Mission Lake	
1)	Camp Knowles	Pit toilets	South of lake.
2)	Boy Scout Camp	Tanks	North of lake.
3)	Skiing Unlimited (Ski Slope)	9800 gallon tank	SW of lake. Property sold: not being used at present.
		D. Katepwa Lake	
1)	Baptist Church Camp	8800 gallon tank Pit disposal for kitchen wastes lagoon under construction.	NW of lake. Tank serviced.
3)	Luther Camp	Tank	West of Lake. Near pelican point. Serviced.

Table 2

SUMMARY OF SEWAGE DISPOSAL FROM COTTAGES

Lake	Total Number of Properties	A Total Number of Cottages 1 (Estimate)	B Total Number of Cottages (Counted)	% of Properties Developed	C Total Serviced by P & F	D Serviced but not by P & F	Total Estimated number of Cottages with leaking tanks.	
							Serviced	Not Serviced
Pasqua	325	240	205	63	122	11	5	1
Echo	634	541	500	79	337	19	9	4
Mission	156	126	122	78	32	10	2	0
Katepwa	780	-	628	81	228	319*	4	6
TOTAL	1895		1455	77	719	359	20	11

(A) Total number estimated from
- i) RM assessment lists
- ii) Fishing lakes mailing lists (Department of Municipal Affairs)
- iii) Personal communication from septic service operators (Pantel and Fort Septic Services)
- iv) Air photos - recent colour photos, 1976; LIFT photos 1976
- v) Topographic maps - Qu'Appelle Implementation office.

(B) Number of cottages or houses counted from air photos and maps.

(C) Number serviced by Pantel Plumbing & Heating Ltd. and Fort Septic Services (Mr. Hahn) only.

(D) Tanks serviced but not by Pantel or Fort Septic Services.

* The village of Katepwa services most of its own cottages.

Table 3A

AQUISITION OF PRELIMINARY INFORMATION

AGENCIES CONTACTED

1) PROVINCIAL

a) Department of Health, Regina.

b) Qu'Appelle Implementation Office, Fort Qu'Appelle.

c) Department of Municipal Affairs, Regina.

d) Department of Tourism and Renewable Resources.

e) Department of the Environment.

2) MUNICIPAL

a) Fort Qu'Appelle office.

b) Village of Katepwa.

c) Lebret.

d) B-say-tah.

e) Rural Municipality #187.

f) Abernathy.

3) PRIVATE

a) Pantel Plumbing and Heating Ltd., Fort Qu'Appelle.

b) Fort Septic Services, Fort Qu'Appelle.

c) Cottage owners and farmers.

Table 3B

AQUISITION OF PRELIMINARY INFORMATION

INFORMATION OBTAINED	SOURCE
i) Number of lots, cottages and septic tanks on the Fishing Lakes.	1b, 1c, 2a, 2b, 2c, 2d, 2e, 2f
ii) Nature and effluent disposal at the cottages. (septic tanks, vaults, tile fields)	1a, 3a, 3b, 3c
iii) Number of cottages regularly serviced.	2b, 3a, 3b, 3c
iv) Estimate of number of cottages not serviced by the commercial operators or the village of Katepwa.	1a, 2b, 3a, 3b, 3c

This has now been restricted to only those cases when the approved sites could not be reached because of poor road conditions. There are several pathways by which the nutrients from septic effluents can enter the local lake system. Fig. 1 shows a schematic of these processes, and they are further discussed below.

1) Seepage from Disposal Sites:

Septic effluents from cottages on Pasqua, Echo and Mission lakes are discharged into the disposal lagoons at Lebret and B-Say-Tah which are both two-cell lagoons. The combined surface area of both the cells is less than 372 square metres (4,000 square feet) at the Lebret site and about 1600 square metres (16,900 square feet) at B-Say-Tah site. Both the disposal sites are situated on generally undulating terrain. The Lebret site is about ½ mile from Mission Lake and the B-Say-Tah site is about 1 mile from Echo Lake. The soil varies from a permeable sandy type to a highly plastic clay type within the seepage field of both the sites. Seepage of effluents through the sides of the lagoons is more likely than downward seepage as the sludge from the raw sewage effectively seals the bottom. (Ref. 16, 17). The village of Katepwa operates its own effluent pumping service and uses a seepage pit at the southeast end of Katepwa Lake for disposal. Nearly 51 percent of the cottages are serviced by the town while approximateiy 36 percent of the cottages are serviced by Fort Septic Services and Pantel Plumbing and Heating Ltd., from Fort Qu'Appelle. There are only about three people who live at the village of Katepwa year round, and almost all cottages are occupied

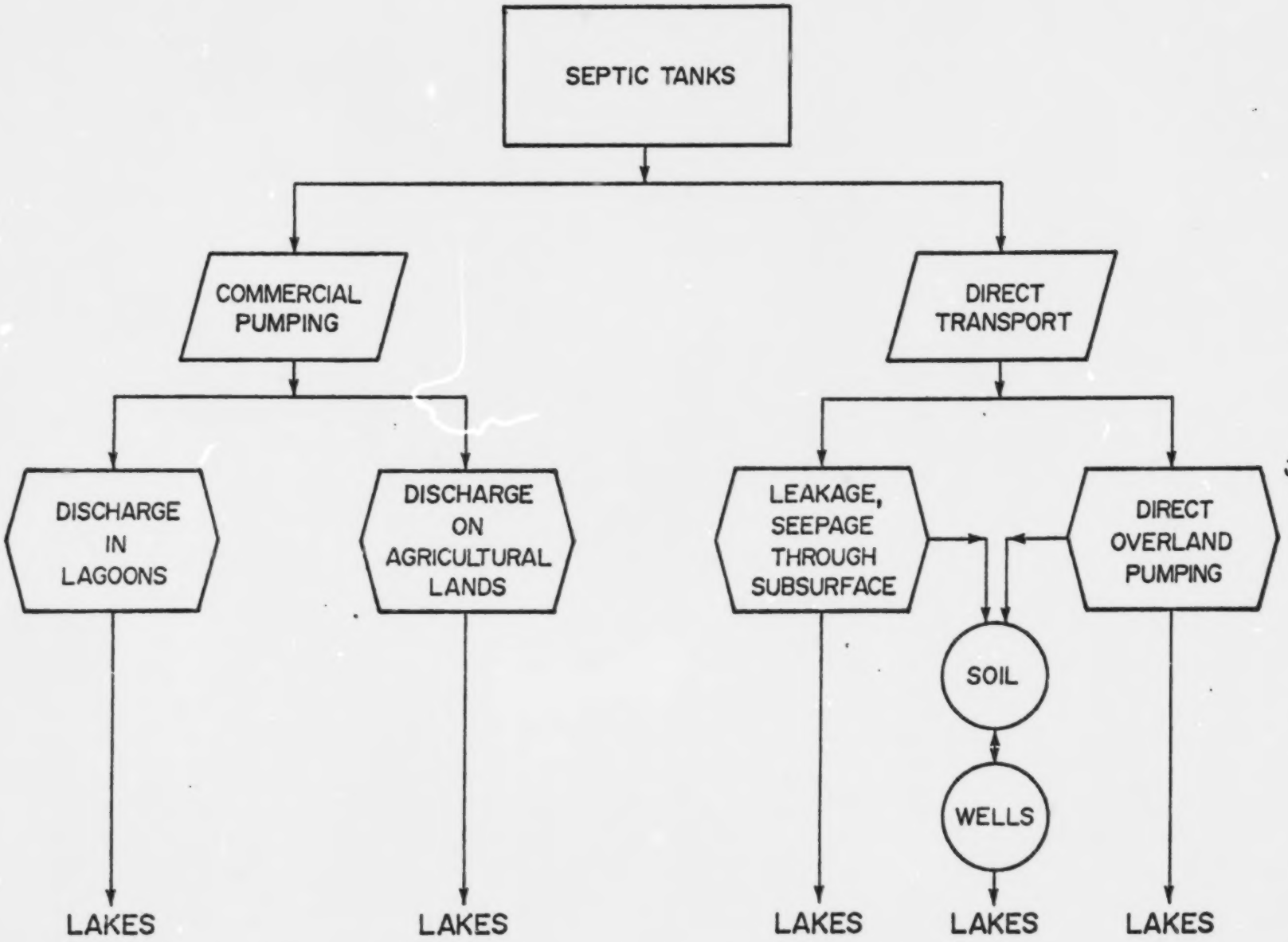


FIG. 1 PATHWAYS OF NUTRIENTS FROM SEPTIC TANKS TO LAKES.

only seasonally. The Lebret site is also used by the Katepwa provincial park and the Echo Valley Centre for sewage disposal. The B-Say-Tah site is used by the fish hatchery and the Evangelical Church group. The Katepwa site is used by that village and also by the Baptist Church Camp and the Lutheran Camp. The Department of Tourism and Renewable Resources maintains a two-cell lagoon southeast of Pasqua Lake which is not discharged. The lagoon is reported to have never been filled up because of high seepage and evapotranspiration rates. The seepage effluent from the Echo Valley Centre (Centre of Arts) undergoes primary treatment at the Centre before it is discharged into Echo Lake. Prairie Christian Training Centre (PCTC) has a campsite system consisting of tanks, tile fields and seepage mounds. Camp Monahan on Katepwa has tile fields at the disposal site. Disposal practices at other recreation and residential sites have been given in Table 1. Sewage effluents are also disposed on several farm sites distributed over the entire area and in the general vicinity of The Fishing Lakes. Table 4 summarizes the data on these disposal sites.

Leakage and Direct Discharge from Septic Tanks:

It is practically impossible to identify the leaking tanks from visual inspection alone. The sensitive nature of the issue as mentioned before simply precluded any easy access to the cottages for inspection. Sampling all cottages or visiting most of them if permitted did not appear to be justified economically or otherwise. The approach taken was to seek the co-operation of the commercial

TABLE 4

APPROVED DOSPOSAL SITES FOR SEPTIC TANK EFFLUENTS

NO.	LAND OWNER	LOCATION	DESCRIPTION	REMARKS	PERMIT HOLDER
1	RM OF NORTH QU'APPELLE#187	NE¼ 7,20,12,W2	GRAVEL PIT, WEST OF KATEPWA.		PANTEL
2	ALBERT SPANNER	NE¼,23,21,15,W2	SLOUGH- UNUSED		PANTEL
3	JOHN SPANNER	S½,23,21,15,W2	SE¼ IN CROP IN 1977 SW¼ SUMMER FALLOW IN1977 SPREAD ON FIELD	SLOPES DOWN TO PASQUA	PANTEL,FORT
4	B-SAY-TAH	NE¼,11,21,14,W2 PARCEL A,PLAN62R 4060	TWO LAGOONS,TOP OF HILL NOT BEING USED LAST USED FALL 1976,SPRING'77	POSSIBLE LEAKAGE FROM LAGOONS. DEEP WELL CLOSE BY	PANTEL,FORT
5	PETER FLETT	SW¼,11,21,14,W2	NEW LAGOON BUILT BY RM #187 AND B-SAY-TAH		PANTEL,FORT
6	VILLAGE OF SANDY BEACH		STRAIGHT UP FROM KATEPWA BEACH	NOT USED BY PANTEL,USED BY FARMERS	PANTEL
7	FORT QU'APPELLE		TOWN LAGOONS	NO DUMPING SINCE 1975	
8	GORDON SKINNER	E½,27,19,12,W2	RM ABERNATHY		PANTEL
9	FRED BROWN	SE¼,24,19,12,W2	RM ABERNATHY		PANTEL
10		EDGELEY,RM SOUTH QU'APPELLE #157			PANTEL
11	W.D.NORTON	W½,35,19,12,W2	RM ABERNATHY		PANTEL
12	L.STEPHENS	SE¼,16,20,12,W2	RM ABERNATHY		PANTEL
13	FRANK REGEL	SW¼,30,21,14,W2	SLOUGH		PANTEL
14	DEPT. OF AGRICULTURE	NW¼,11,21,13,W2	RM FORTQU'APPELLE LAGOONS AT LEBRET AT NUISANCE GROUNDS		PANTEL, FOR
		[illegible]	NORTH OF ECHO LAKE		FORT

septic services and separate their clientele from the total number of cottage owners on The Fishing Lakes. The difference would be the number of cottages not serviced by the commercial operators for any of the following reasons.

1) The owner services his own tank

2) No need to service the tanks because of limited or no occupancy

3) Leaking septic tanks

4) Direct discharge into lake

or 5) The existence of tile fields or mounds.

Because of budgetary constraints it was not possible to investigate further to determine the exact number of cottages under categories 3, 4 and 5. However, by interviewing the commercial operators and local residents it was possible to arrive at approximate numbers which are given in Table 2, column 7 and 8. They refer to the suspected number of cottages serviced or unserviced. From the table it appears that about 75% of the cottages on all The Fishing Lakes are being serviced. During the study a boat-run on The Fishing Lakes was taken to identify direct discharges from cottages into lakes. This proved to be inconclusive because of the multiplicity of pipes that could be seen projecting from many cottages. However, several samples were taken from the lake water in the vicinity of some cottages to substantiate suspicions. These are dealt with in the following sections.

FIELD DATA

Soil Data

1) Disposal Lagoons:

Except in the case of direct discharges, effluent from leaking septic tanks or the disposal sites seep through soil strata before entering the lakes. The ability of the soil to act as a living filter has been effectively used in the disposal of wastes in recent years. (Ref. 17, 18). To determine the attenuation in the transport of phosphates within the soil zone, test holes were augured at various distances from the disposal lagoons and core samples taken for analysis. These were hand augured holes approximately 3 metres in depth at most sites. Figures 2 to 4 show the location of various test holes. Test holes in most cases were aligned in the general direction of sub-surface flow.

Lebret Disposal Site

Figure 2 shows the general orientation of the lagoon cells and a landfill between them. The ridge that runs east-west affects the surface drainage of the area. The disposal site is approximately half-a-mile from Mission Lake. The direction of surface drainage is from the ridge northwards away from the lake. Initially the holes numbered from 1 to 5 and from 7 to 17 were drilled to collect core samples. On a later trip holes 29 and 30 were augured to obtain soil and seepage data close to the lagoon. Lagoon #1 overflows to a coulee from its north-west corner but this does not appear to be a frequent occurrence. Holes at lagoon #1 were aligned in the north-south direction which coincides with the direction of subsurface and

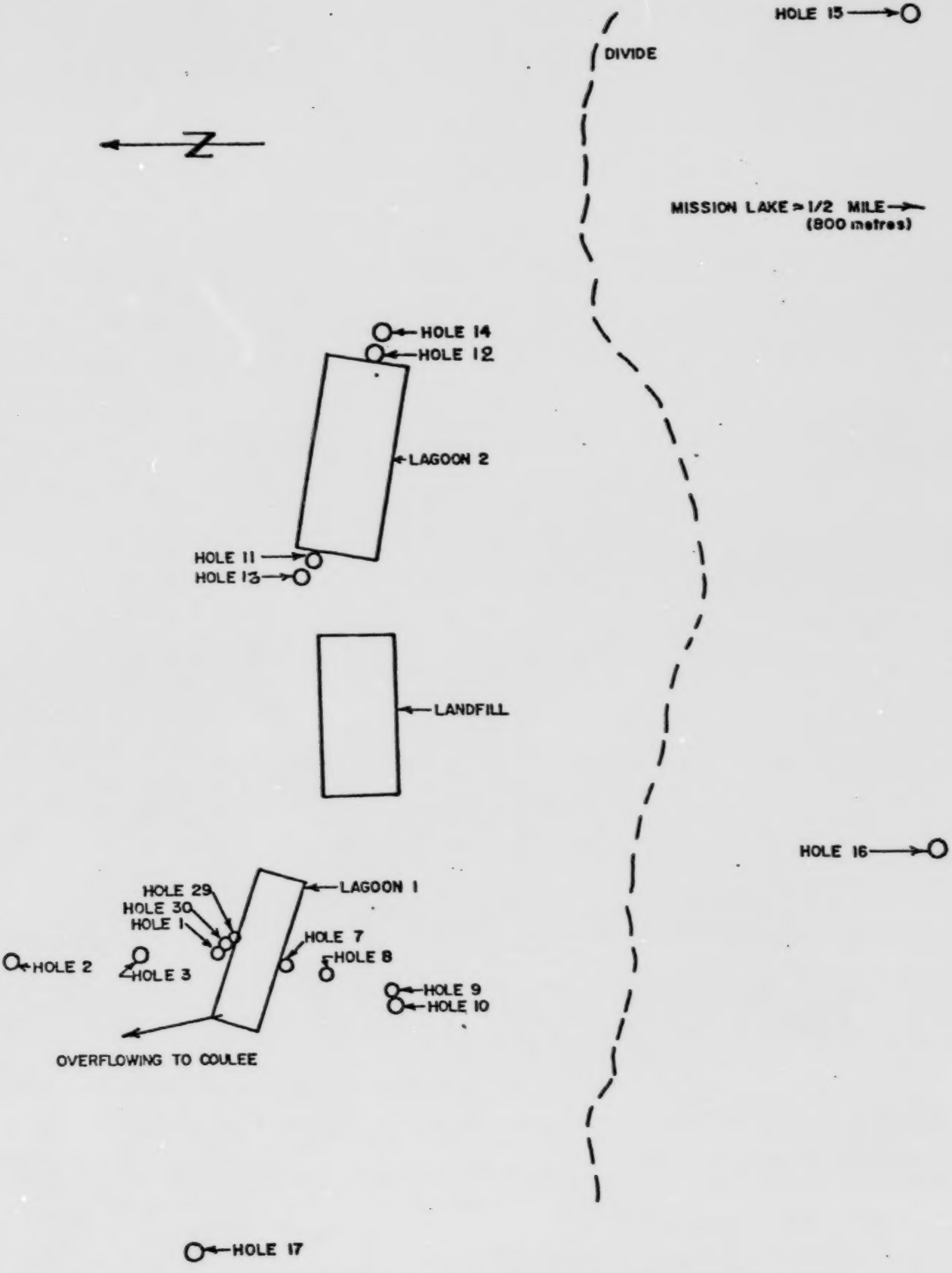


FIG. 2: TEST HOLE LOCATIONS AT THE LEBRET DISPOSAL SITE

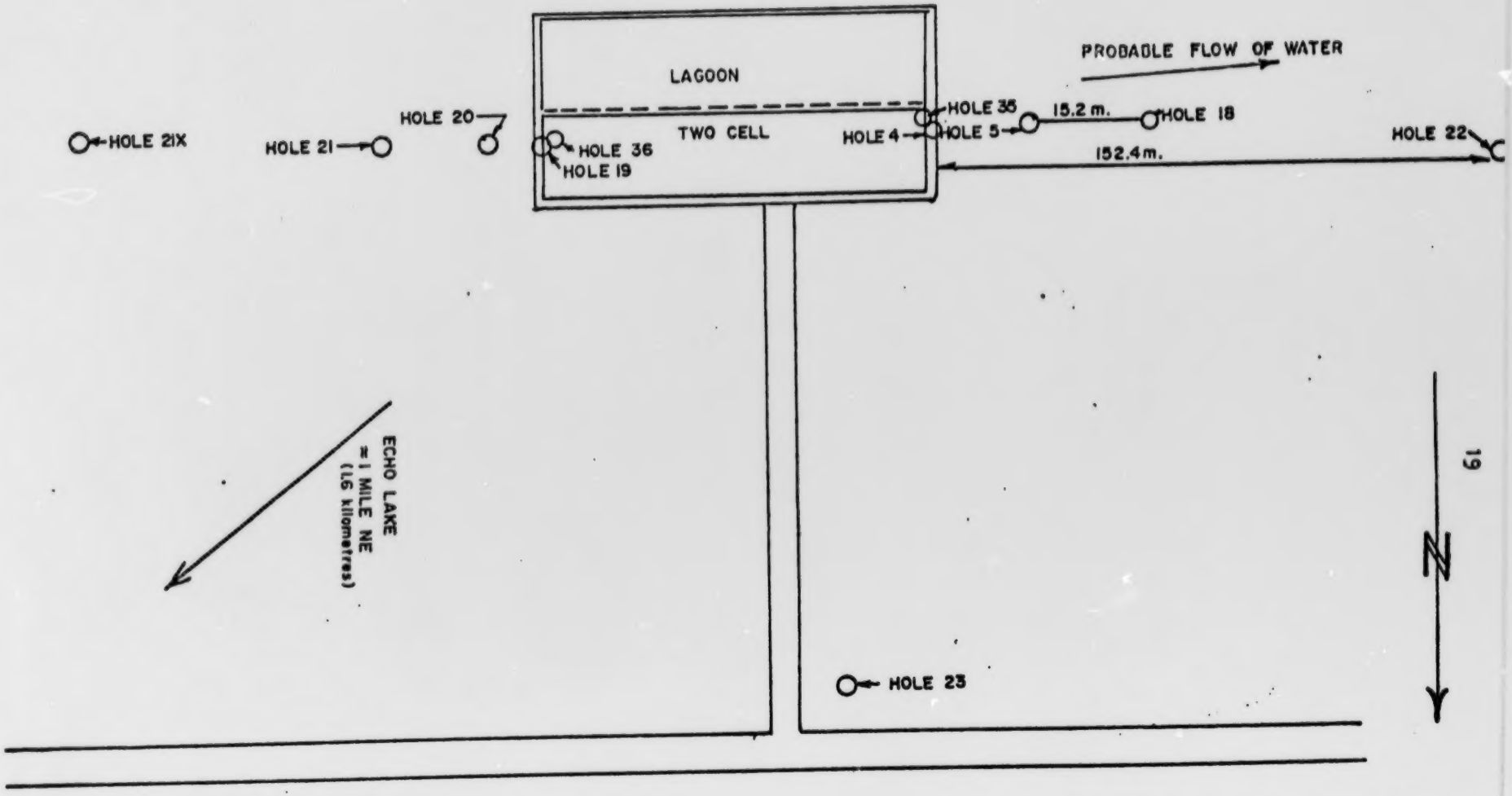


FIG. 3: TEST HOLE LOCATIONS AT THE B-SAY-TAH DISPOSAL SITE

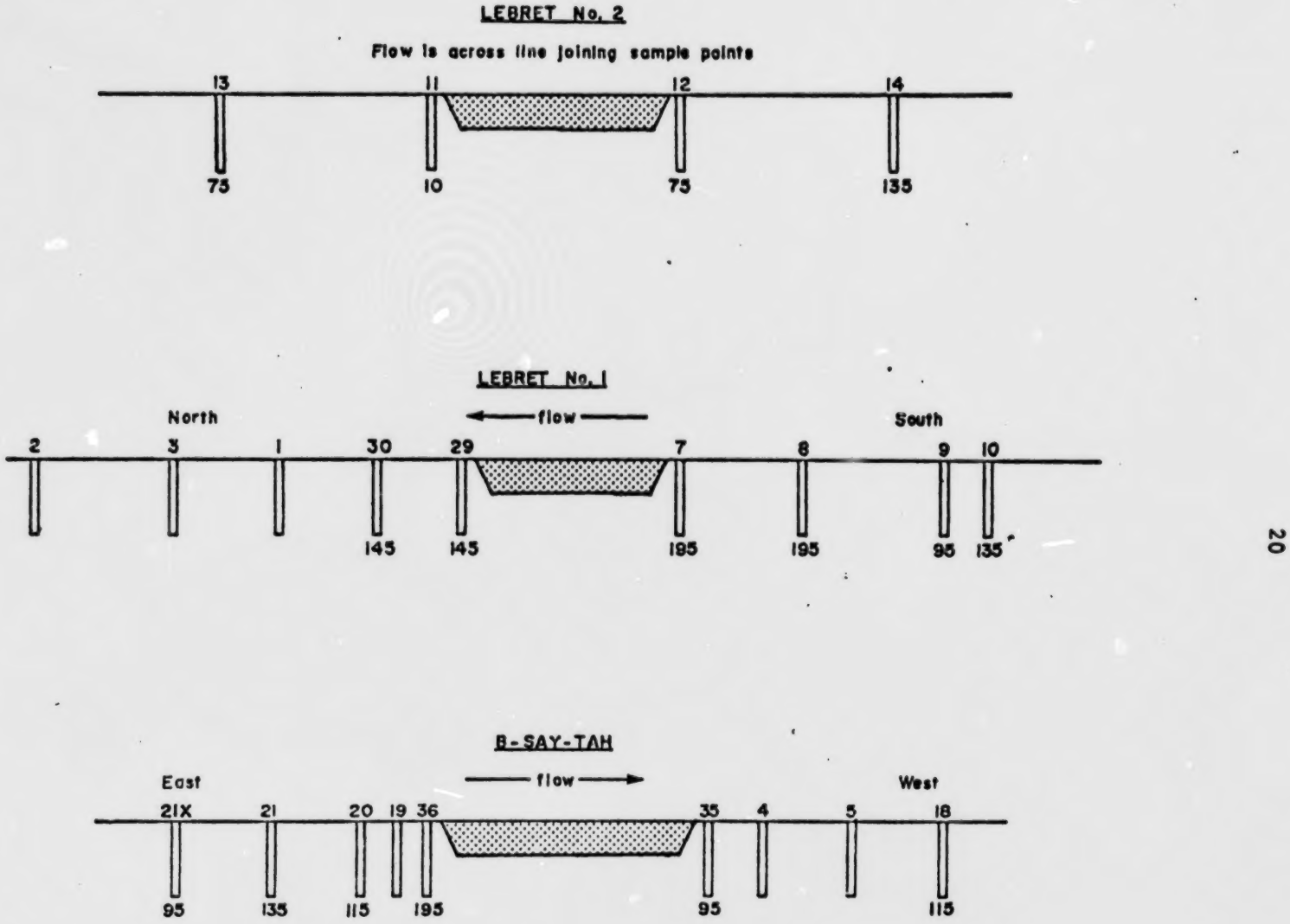


FIG. 4: VERTICAL CROSS SECTION OF DISPOSAL LAGOONS

surface drainage. Holes at lagoon #2 were aligned approximately in the east-west direction. All the holes, augured to a depth of approximately 3 metres, beyond a distance of 1 metre towards north and less than a metre towards south were dry. At lagoon #2 all holes were dry. Holes numbered 15, 16 and 17 were used to obtain the background samples representative of the general area.

B-Say-Tah Disposal Site

Figure 3 shows the position of test holes with respect to the lagoon. There are two cells in the lagoon and the lagoon is about one mile south-west of Echo Lake. Surface drainage is in the east-west direction. Ten test holes were augured at various distances from the lagoon and only the holes numbered 4 and 19 at a distance of 75 cms and 100 cms respectively from the edge of the lagoon were not dry. Test holes 35 and 36 about 30 cms from either edge of the lagoon and angled to be parallel to the sidewalls were dry at an angled depth of 3 metres.

Summary of test holes with approximate lithology is given in Tables 5A to 5C for Lebret and B-Say-Tah sites. Figure 4 shows the cross sectional view of test holes with respect to the lagoons.

Cottage Sites:

Two cottages were selected one on Pasqua and another on Echo Lake to determine the effect of soil on subsurface transport of phosphates. In spite of the fact that both the cottages were known to have leaking septic tanks, the cottage owners permitted sampling from the test holes, wells, and the septic tanks. These sites are referred to in this report as Pasqua and Echo cottages. Figures 5

Table 5A

TEST HOLE DATA

A. Disposal Site Lebret Lagoon # Test Hole Data

Hole #	Depth(cm)	% Moisture (Dry wt. Basis)	Approximate Lithology/Remarks
1	0-20		Very fine silty sand.
	20-40		Brownish yellow, very fine silty sand, uniform
	40-50		" " " " " " "
	90-100		" " " " " " "
	140-150		" " " " " " "
	150-160		Very fine sand, silty wet
	160-170		" " " and silt/clay, plastic, wet
	170-180		Sandy clay, stiff/plastic, iron oxidation streaks.
	190-120		Fine silty sand, greyish to white, black particles
	230-240		" ", grey clay lenses
	250-260		Fine sand, greenish/grey, clay streaks, plastic.
	260-280		" " " silty
	280-290		Stiff clay, dark brown to light brown
	290-300		" " " " " "
2	0-20		Loose brown topsoil, dry
	20-40		" " ,fine sand, silty
	50-60		Fine silty sand
	90-100		Very fine silty sand, yellowish
	130-140		" " " " dry
	150-160		" " " " "
	190-200		Sandy clay, grey to brown
	210-220		Fine silty sand, clay lenses, brown to light brown
	230-240		Very fine silty sand
	250-260		" " "
	270-280		Brown, grey clay, white(calcareus)spots, small roc
	290-300		" " " " " " " "
3	0-20		Topsoil
	30-40		Silty very fine sand, yellow brown to white in col
	50-60		" " " " " " " "
	70-80		" " " " " " " ,sti
	90-100		" " " " " " " "
	130-140		" " ", stiff, greyish
	150-160		" " " " " "
	170-180		Sandy clay, stiff, plastic, white streaks
	190-200		Fine silty sand, wet
	250-260		" " "
	270-280		Very stiff oxidized till, grey to brown, small pebbles.

Table 5A

TEST HOLE DATA

A. Disposal Site Lebret Lagoon # Test Hole Data

Hole #	Depth(cm)	% Moisture (Dry wt. Basis)	Approximate Lithology/Remarks
7	0-20		Topsoil
	30-40	11.6	Fine silty sand, yellow
	50-60	10.4	" " "
	130-140	24.4	" " grey
	150-160	35.6	" " ", wet
	170-180	43.0	Sandy clay, grey, wet
	210-220	28.7	Fine grey white clean sand
	270-280	34.6	Silty sand, dark grey to yellow brown, wet, crumb
	290-300	33.8	" " " " " " " "
	310-320	41.5	Disturbed till, dark grey to brown, crumbly
	330-340	33.9	Wet silty sand
8	0-20		Topsoil, disturbed, brown
	30-40	15.5	Fine silty sand, yellow
	50-60	9.8	Very fine filty sand, dry
	150-160	13.5	" " ", grey white, moist
	210-220	35.1	Fine sandy clay, grey
	230-240	16.5	Fine yellow brown sand, streaks of clean sand
	250-260	33.4	" " " " " " " wet
	290-300	15.7	Sandy clay
9	0-20		Topsoil, disturbed, dark brown
	30-40	9.1	Very dry white silt, slightly sandy
	50-60	7.3	" " " " " ",calcereous
	100-120	5.6	" yellowish " " " " "
	130-140	13.1	" " " " " " "
10	30-40	11.4	Silt, slightly sandy, calareous powder
	50-60	7.3	" " " " " "
	110-120	24.9	" " " " " till plates moi
	150-160	28.7	" " " " " "
	170-180	10.0	Very fine silty sand, yellow
	230-240	12.8	" " " clay streaks
	250-260	14.5	" " " " " 0.5mm angular pebble

Table 5A

TEST HOLE DATA

A. Disposal Site Lebret Lagoon # Test Hole Data

Hole #	Depth(cm)	% Moisture (Dry wt. Basis)	Approximate Lithology/Remarks
29	40-50	10.2	Very fine silty sand, moist
	90-100	8.5	" " " "
	160-170		Grey sand, wetter
	180-190		Grey, silty, clayey sand
	200-210	13.0	Whitish sand, moist
	240-250	25.7	Grey silty clay, layered fine sand streaks, moist
	250-260		Very fine grey sand, wet
	270-280		" " " "
	290-300	28.2	Moist clay, dark brown and grey
30	40-50	7.3	Very fine silty sand, moist, brownish yellow
	90-100	7.2	" " " ",grey mostly
	160-170		Grey silts clay, moist
	200-210	9.9	Light grey fine sand, moist
	240-250	24.2	Grey sandy clay, moist
	260-270		" silty " "
	290-300	28.8	Clay, dark-brown and grey

Table 5B

TEST HOLE DATA

B. Disposal Site Lebret Lagoon #2 Test Hole Data

Hole #	Depth(cm)	% Moisture (Dry wt. Basis)	Approximate Lithology/Remarks
11	0-20	48.3	Black oily, sandy, plastic soil
	30-40	48.0	Olive brown to dark grey, crumbly, calcereous concentrations.
	90-100	39.0	Fine wet sand
	110-120	39.2	" "
12	10-20	48.9	Dark grey and yellow brown till
	50-60	42.2	" " " " ", pebbles
	90-100	37.7	Wet, very fine silty sand
13	30-40	8.5	Fine, silty, yellow to white sand
	50-60	21.8	" " " " " ,loose till mixed
	70-80	44.0	Loose till, olive brown to dark grey, salt concentrations platey
	150-160	48.5	Fine, silty sand
	230-240	38.1	Olive brown to dark grey till, small pebbles
	250-260	31.3	Find sand, yellow brown, moist
	270-280	42.3	Dark grey to yellow brown till
14	10-20	47.0	Olive brown to dark grey till
	30-40	38.9	" " " " "
	50-60	32.2	Fine silty sand
	110-120	44.5	" ", wet, plastic
	150-160	26.0	Black grey to yellow brown till
	190-200	55.2	" " " " "

Table 5C

TEST HOLE DATA

C. Disposal Site B-Say-Tah Lagoon

Hole #	Depth(cm)	% Moisture (Dry wt. Basis)	Approximate Lithology/Remarks
4	0-10		Topsoil
	20-30		Dark grey clay, oxidized, non-calcareous, very sti
	40-50		Light grey clay, oxidized
	120-130		Grey till, streams of white material, calcareous
	140-150		Dark grey till, calcareous stiff.
	210-220		Yellowish brown till
	230-240		Dark grey till, yellowish brown streaks, pebbles &
	290-300		" " " " " " " roc
5	0-10		Topsoil
	20-30		Dark brown non-calcareous clay(slit)mixed with to
	70-80		Grey & yellowish, calcareous oxidized till. soi
	90-100		Dark grey, stiff, oxidized calcareous till
	130-140		Brown clay, calcareous, small rock
	190-200		" " " " " "
18	0-20	13.9	Black topsoil
	50-60	14.2	Sandy clay silt, loose, calcareous
	130-140	17.4	" " " stiff, "
	170-180	18.6	Dark grey silt
	190-200	17.1	Dark brown stiff till, calcareous
19	0-30	13.0	Dark material, grey
	70-80	26.3	Dark grey silt & clay, high plasticity
	150-160	21.8	Grey to yellow-brown clay
	190-200	31.1	Yellow-brown clay, streaks of oxidized material
	210-220	30.7	Red-brown clay
20	0-20	12.8	Topsoil
	90-100	20.9	Dark green to brown clay, non-calcareous
	110-120	28.7	Grey to yellow clay, calcareous, salt concentrati
	150-160	27.3	Brown to grey till
	270-280	28.6	Dark grey, stiff till, small pebbles

Table 5C

TEST HOLE DATA

C. Disposal Site B-Say-Tah Lagoon (con't)

Hole #	Depth(cm)	% Moisture (Dry wt. Basis)	Approximate Lithology/Remarks
21	0-30		Brown topsoil
	30-40	18.9	Yellow-brown, sandy till, loose
	50-60	20.9	" " " " " , calcareous
	110-120	24.1	Yellow brown silt, calcareous
	170-180	24.7	" " " "
35	40-50		Clay, (stiff), moist
	70-80		Bluish sandy clay with rust streaks.
	90-100	27.3	Grey-brown clay. Very plastic & stiff
	140-150		" " Calcareous
	190-200	24.9	Yellow-brown crumbly clay
	280-290	24.8	Dark brown clay till
36	40-50		Dark brown clay, moist
	90-100		" " stiff
	190-200		Grey-brown, silty sand

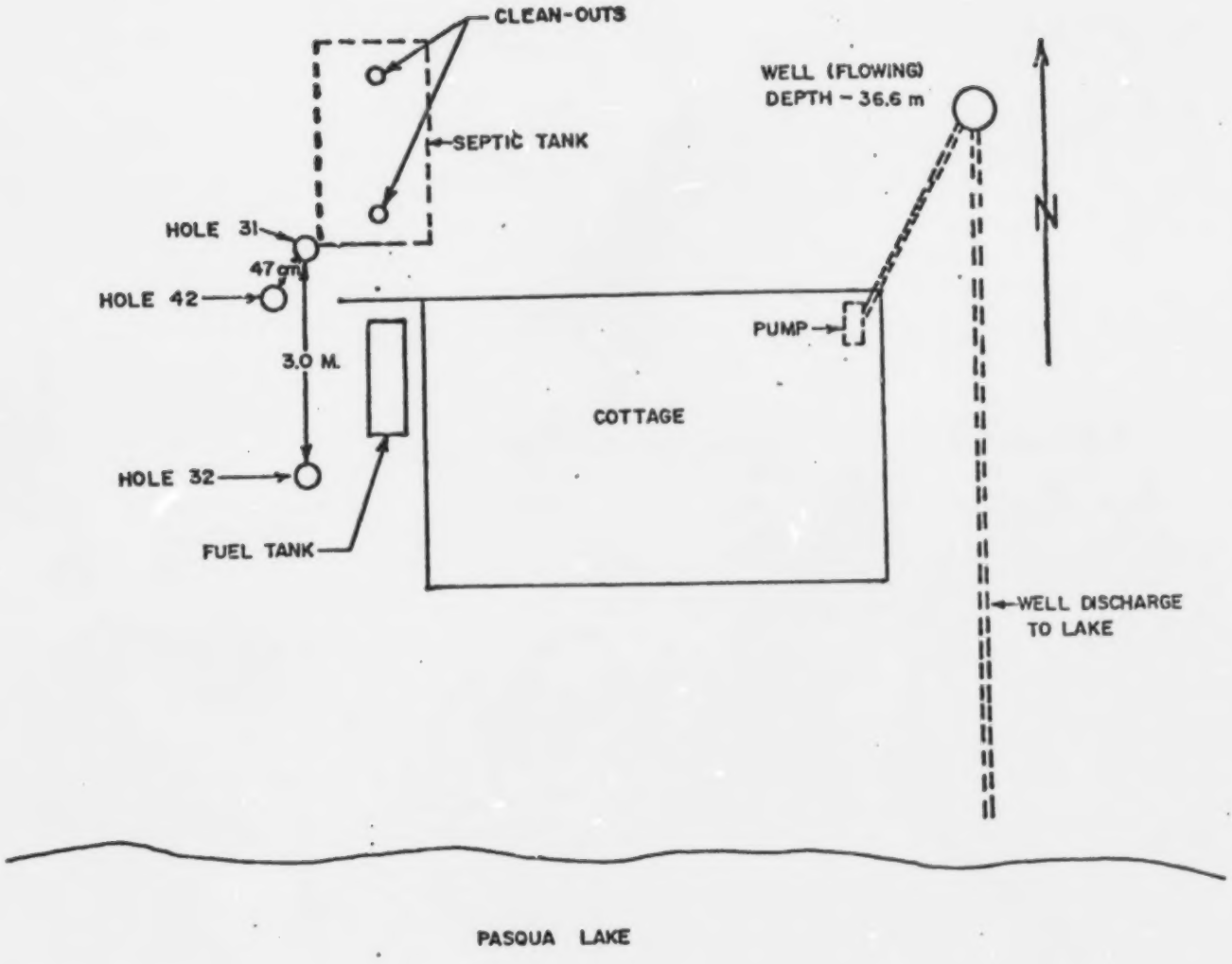


FIG. 5: TEST HOLE LOCATIONS AT THE PASQUA COTTAGE SITE

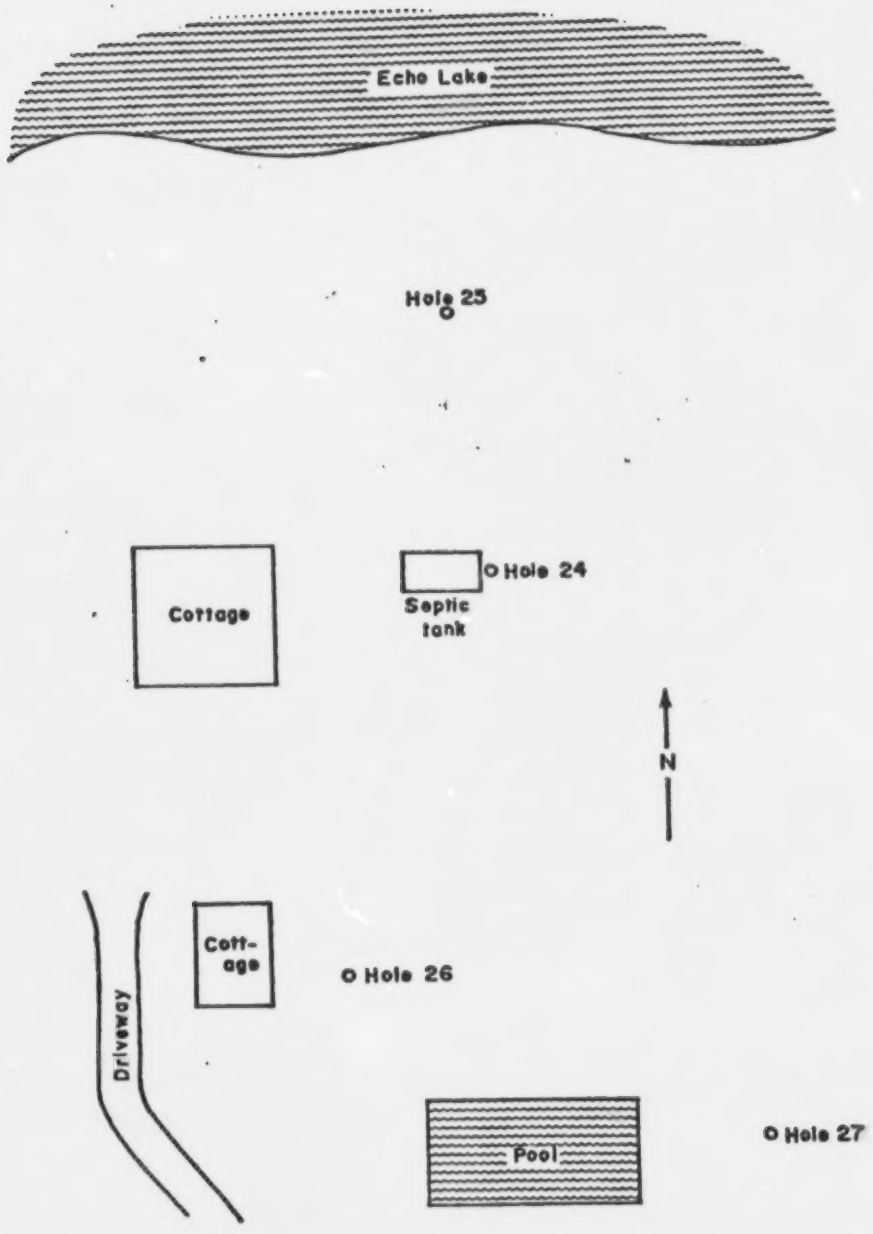


FIG. 6: TEST HOLE LOCATIONS AT THE B-SAY-TAH (ECHO) COTTAGE #313

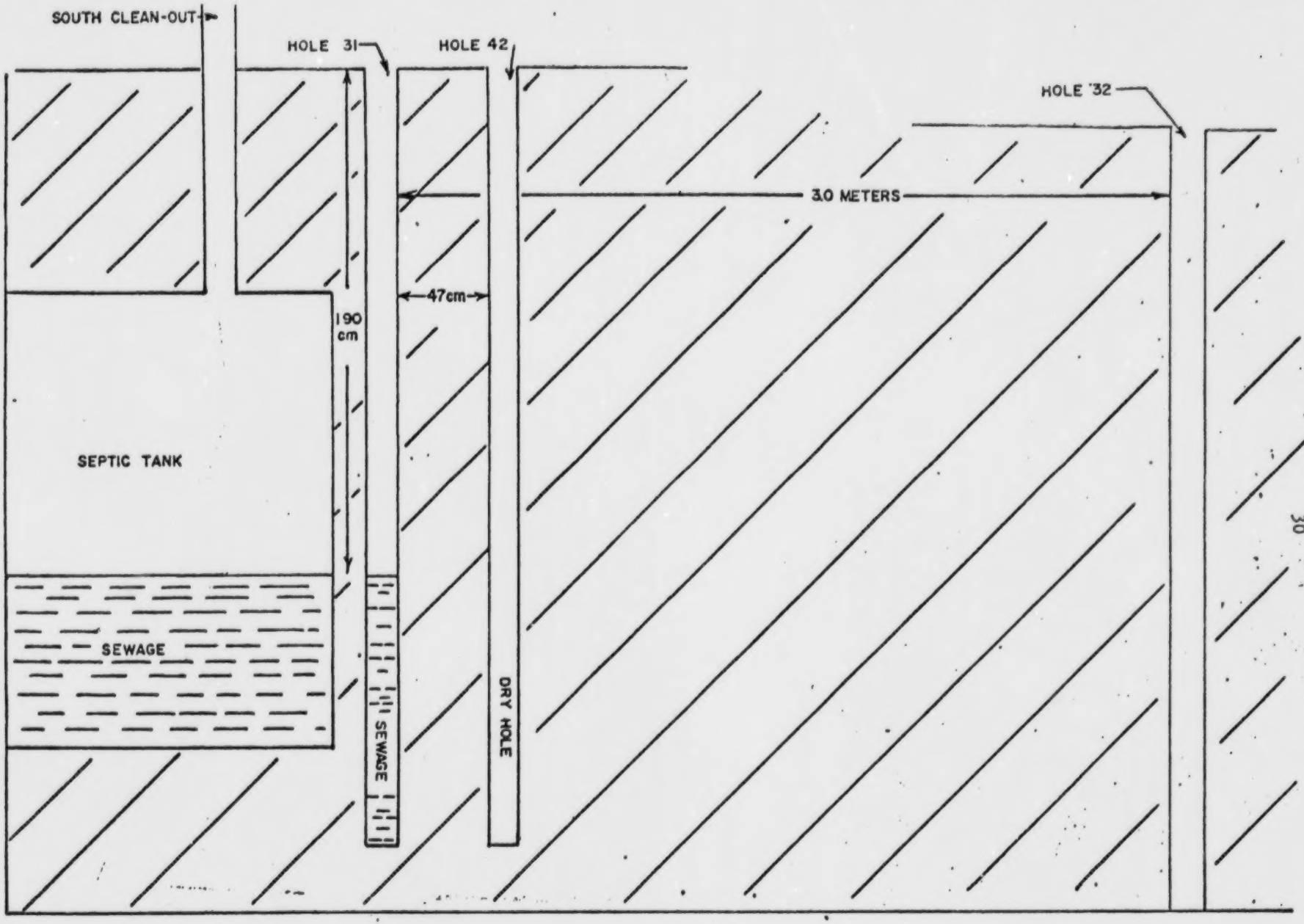


FIG.7. VERTICAL CROSSSECTION OF PASQUA COTTAGE SITE.

and 6 show the location of test holes at the cottage sites. Pasqua cottage was particularly useful as we were able to drill test holes very close to the leaking septic tank and at distances of 47 cms and 3 metres from it towards the lake. Figure 7 shows vertical cross section of the septic tank and test holes at the Pasqua cottage. Septic effluent from the leaking tank seeped readily into hole #31 but the hole #42 at approximately 47 cms from hole #31 was dry at the time of drilling as was hole #32 about 3 metres away. Seepage flow slowly collected in holes #31 and 42 after several days. The cottage is about 31 metres from the lake edge. Test hole data are given in Tables 5D and 5E.

Tile Fields

There are several cottages on The Fishing Lakes which use shallow tile fields to discharge their effluents. Prairie Christian Training Centre (PCTC) on Echo employs a large tile field about 35 feet wide and about 5 feet deep. Test holes numbered 37 and 43 were put in to obtain samples from the tile field. Test hole data are given in Table 5F.

Background Samples:

In addition to the background samples taken from test holes at Lebret and B-Say-Tah disposal sites, several samples were taken from the valley bottom. They were taken at Lebret, between Pasqua and Echo Lakes, Katepwa village point and a site upstream of Katepwa village. The low lying area in the seepage zone of Fort Qu'Appelle's town lagoon was chosen for an additional sampling site. This site

Table 5D

TEST HOLE DATA

D. . Disposal Site .Pasqua Cottage.

Hole #	Depth(cm)	% Moisture (Dry wt. Basis)	Approximate Lithology/Remarks
31	40-50	7.2	Light brown sandy clay - moist
	140-180	26.0	Sandy clay with black organic matter
	190-200	22.9	Same.
	240-250	26.7	Same.
	290-300	18.9	Yellow-brown sandy clay.
32	40-50	5.9	Light brown silty sand.
	140-150	12.7	Same.
	190-200	13.0	Yellowish brown silty sand.
	290-300	17.9	Loose, sandy clay with small pebbles.
42	40-50		Light brown, sandy clay.
	90-100		Brown, sandy clay mixed with black topsoil.
	140-150	22.2	Same.
	190-200	29.6	Black organic matter.
	240-250	25.5	Same.
	260-270	25.5	Yellow-brown clay.
	290-300	15.5	Yellow-brown sandy mixed with clay.

Table 5 E

TEST HOLE DATA

E. Cottage Sitee B-Sah-Tah (Echo) Cottages #313 & #54

Hole #	Depth(cm)	% Moisture (Dry wt. Basis)	Approximate Lithology/Remarks
24	0-30		Gravely, black topsoil.
	30-40	13.6	Black, sandy clay.
	50-60	13.0	Loose, sandy, red-brown clay.
	70-80	13.0	Sandy clay-gravel. Very humus.
	90-100	25.6	Same.
	110-120	19.1	Grey, silty, coarse sand.
	150-160	22.5	Same.
25	30-40	20.0	Dark, sandy humus topsoil.
	50-60	6.6	Silty clay mixed with coarse sand & gravel.
	110-120	26.9	Mixed clay, sand & gravel. Calcareous.
	170-180	20.9	Dark grey sand & gravel.
	190-200	20.4	Light grey silty sand.
26	0-20	27.2	
	30-40	27.2	Topsoil. Black silty sand with gravel.
	50-60	12.7	Same.
27	0-40		Black silty medium sand topsoil with grave
	50-60	11.2	Same.
	70-80	13.7	Grey-yellow coarse silty sand with gravel.
	90-100		Same.
28	30-40	5.8	Coarse heterogeneous sand & gravel.
	50-60	12.0	Same.

Table 5 F

TEST HOLE DATA

F. Disposal Site PCTC Field

Hole #	Depth(cm)	% Moisture (Dry wt. Basis)	Approximate Lithology/Remarks
37	20-30	9.8	Loam topsoil.
	40-50	14.5	Loam sandy clay.
	70-80	20.3	Grey-brown clay.
	110-120	15.4	Grey clay with pebbles.
	140-150	18.5	Yellow-brown sandy clay.
	160-170		Light grey sand.
	270-280	5.6	Yellow gravel.

This site would probably be influenced by the town lagoon. The data on these sites are summarized in Table 5G.

Water Sampling:

Surface water samples were obtained from the disposal sites, village lagoons and lake water in front of several cottages suspected of either discharging effluent directly into the lake or operating a leaky septic tank. Water samples were also taken from test holes that had standing seepage from effluent sources. Both deep and shallow wells at the cottages and villages were sampled as well as several public springs.

Analysis of Soil and Water Samples

Initial soil samples obtained from holes numbered 1 to 6 were analyzed at the Soil Testing Laboratory of the University of Saskatchewan. Total phosphates were determined but the soil moisture values for individual samples were not done. Because of the delay experienced in completing the analysis, further analysis of samples was done at the Saskatchewan Research Council's analytical laboratory. The samples were analyzed for total phosphorus (as phosphates), inorganic phosphorus (as phosphates) and water soluble chlorides.

Analysis for total phosphates was done by perchloric acid digestion followed by suitable dilution and using the autoanalyser for final read-out. Inorganic phosphorus (given as phosphates) was obtained by sulphuric acid digestion at 90°C for 45 minutes followed by a suitable dilution and using the autoanalyser for final read-

Table 5 G

TEST HOLE DATA

G. Disposal Site Background

Hole #	Depth(cm)	% Moisture (Dry wt. Basis)	Approximate Lithology/Remarks
		B-SAY-TAH LAGOON- EAST	
21X	30-40	17.7	Yellow-brown loose topsoil.
	50-60	11.3	Yellow-beige sandy silt - loose calcareous.
	150-160	4.7	Sandy silt. Calcareous.
	170-180	14.1	Fine Sandy silt mixed with dark brown plat
	190-200	13.2	Same.
	210-220		Same.
		B-SAY-TAH LAGOON - WEST	
22	0-20		Black topsoil.
	30-40	17.8	Black sandy silt topsoil. Stiff.
	50-60	16.0	Same.
	130-140	20.9	Grey calcareous till.
	150-160	21.2	Same.
	190-200	26.4	Yellow calcareous till.
	210-220	26.1	Same.
		LEBRET LAGOON #2	
15	0-20	8.6	Black topsoil.
	30-40	6.7	White sandy silt. Calcareous.
	50-60	8.7	Same.
	150-160	11.7	Same.
	170-180	4.8	Fine yellow sand.
	190-200	5.2	Same.
		LEBRET LAGOON #1	
17	0-20		Disturbed topsoil.
	30-40	6.8	Black topsoil.
	50-60	4.1	Fine sandy silt.
	70-80	3.8	Fine brown silty sand.
	150-160	3.6	Same.
	230-240	13.9	Same.

out. Water soluble chlorides were determined by boiling the soil sample in deionized water fro 15 minutes and titrating the leachate with Ag NO_3 of 0.1N normality. Water soluble chlorides were used as a tracer to determine the presence of sewage contaminated seepage. The water samples were analysed for total phosphorus (as phosphates), total organic carbon, water soluble chlorides and pH. For total phosphorus and water soluble chlorides the same digestion and titration procedures were used as for soil samples. Auto carbon analyser was used to determine total organic carbon. Soil moisture values were obtained by the gravimetric method by weighing the sample before and after air drying and the values are expressed as a percentage of the dry sample weight. Soil analysis data are presented in Tables 6A to 6H. Water analysis data are given in Tables 7A to 7H. Total phosphates, inorganic phosphates and water soluble chlorides from soil analysis are expressed as percentages with respect to the dry samples.

PHOSPHATE ADSORPTION IN SOILS

Phosphate values from the lagoon samples and the water samples from test holes have been plotted as a function of the distance from the lagoon in Fig. 8. There is a significant reduction in the phosphate concentration even at short distances. As most of the holes were dry at a depth of 3 metres water sample data from test holes were limited. The reduction in phosphates is not progressive with distance but occurs within a very short distance between the lagoon and the first test hole. It appears that the lagoon sidewalls and

Table 6A

ANALYSIS OF SOIL SAMPLES

Disposal Site: Lebret Lagoon #1, South

Hole #	Distance from Lagoon (metres)	Sample Depth (cms)	Leachate Analysis		
			Total Extractable Phosphates (% Dry Sample)	Inorganic Phosphates (% Dry sample)	Water Soluble Chlorides (% Dry Sample)
#7	1.0				
7-2		50- 60	0.159	0.149	0.005
7-7		150-160	0.174	0.167	0.005
7-14		290-300	0.167	0.166	0.005
#8	8.6				
8-2		50- 60	0.161	0.157	<0.002
8-7		150-160	0.170	0.170	<0.002
8-14		290-300	0.169	0.155	<0.002
#10	23.9				
10-2		50- 60	0.169	0.158	<0.002
10-7		150-160	0.169	0.157	<0.002
10-12		250-260	0.156	0.155	<0.002

ANALYSIS OF SOIL SAMPLES

Disposal Site: Lebret Lagoon #1, North

Hole #	Distance from Lagoon (metres)	Sample Depth (cms)	Leachate Analysis		
			Total Extractable Phosphates (% Dry Sample)	Inorganic Phosphates (% Dry sample)	Water Soluble Chlorides (% Dry Sample)
#29	0.19				
29-2		90-100	0.170	0.150	0.0006
29-4		200-210	0.120	0.120	0.0003
29-5		240-250	0.140	0.140	0.0001
29-6		290-300	0.160	0.120	0.0003
#30	0.40				
30-2		90-100	0.140	0.140	0.0003
30-4		200-210	0.120	0.120	0.0003
30-5		240-250	0.150	0.150	0.0002
30-6		290-300	0.180	0.130	0.0003
#1	1.00				
1-4		40- 50	0.147		
1-9		90-100	0.157		
1-14		140-150	0.149		
1-19		190-200	0.129		
1-23		230-240	0.145		
1-27		280-290	0.144		
#3	8.62				
3-3		50- 60	0.145		
3-5		90-100	0.152		
3-8		150-160	0.156		
3-10		250-260	0.155		
#2	23.9				
2-3		50- 60	0.107		
2-5		90-100	0.110		
2-8		150-160	0.161		
2-10		190-200	0.153		
2-13		250-260	0.149		
2-14		270-280	0.145		

Table 6C

ANALYSIS OF SOIL SAMPLES

Disposal Site: Lebret Lagoon #2

Hole #	Distance from Lagoon (metres)	Sample Depth (cms)	Leachate Analysis		
			Total Extractable Phosphates (% Dry Sample)	Inorganic Phosphates (% Dry sample)	Water Soluble Chlorides (% Dry Sample)
#13	4.00				
13-2		50- 60	0.163	0.149	0.005
13-7		150-160	0.138	0.134	0.009
13-12		250-260	0.164	0.164	0.005
#14	2.50				
14-2		30- 40	0.167	0.158	<0.002
14-8		150-160	0.184	0.162	0.011
14-10		190-200	0.161	0.156	0.014

Table 6D

ANALYSIS OF SOIL SAMPLES

Disposal Site: B-Say-Tah Lagoon (Westward)

Hole #	Distance from Lagoon (metres)	Sample Depth (cms)	Leachate Analysis		
			Total Extractable Phosphates (% Dry Sample)	Inorganic Phosphates (% Dry sample)	Water Soluble Chlorides (% Dry Sample)
#35	0.30				
35-2		90-100	0.180	0.150	
35-4		190-200	0.160	0.130	
35-6		280-290	0.150	0.130	
#18	23.50				
18-2		50- 60	0.179	0.136	<0.002
18-6		130-140	0.190	0.149	<0.002
18-9		190-200	0.177	0.152	<0.002

Table 6E

ANALYSIS OF SOIL SAMPLES

Disposal Site: Pasqua Cottage

Hole #	Distance from Septic tank (metres)	Sample Depth (cms)	Leachate Analysis		
			Total Extractable Phosphates (% Dry Sample)	Inorganic Phosphates (% Dry sample)	Water Soluble Chlorides (% Dry Sample)
#31	Adjacent				
31-3		140-150	0.250	0.210	0.0002
31-4		190-200	0.260	0.230	0.0002
31-6		240-250	0.390	0.370	0.0003
31-7		290-300	0.180	0.170	0.0002
#42	0.47				
42-3		140-150	0.245	0.210	0.0002
42-4		190-200	0.240	0.180	0.0004
42-5		240-250	0.230	0.190	0.0003
42-6		290-300	0.180	0.150	0.0009
#32	3.00				
32-3		140-150	0.160	0.150	0.0006
32-6		290-300	0.160	0.150	0.0002

Table 6F

ANALYSIS OF SOIL SAMPLES

Disposal Site: PCTC Field

Hole #	Distance from Source (metres)	Sample Depth (cms)	Leachate Analysis		
			Total Extractable Phosphates (% Dry Sample)	Inorganic Phosphates (% Dry sample)	Water Soluble Chlorides (% Dry Sample)
#37	middle of field				
37-2		40- 50	0.240	0.190	
37-5		110-120	0.250	0.180	
37-9		250-260	0.130	0.110	

Table 6G

ANALYSIS OF SOIL SAMPLES

Disposal Site: B-Say-Tah (Echo) Cottage #313

Hole #	Distance from Septic tank (metres)	Sample Depth (cms)	Leachate Analysis: Total Extractable Phosphates (% Dry Sample)	Leachate Analysis: Inorganic Phosphates (% Dry sample)	Leachate Analysis: Water Soluble Chlorides (% Dry Sample)
#24	Adjacent				
24-2		50- 60	0.120	0.096	<0.002
24-4		90-100	0.257	0.196	<0.003
24-7		150-160	0.110	0.101	<0.002
#25	Between tank and lake				
25-2		50- 60	0.123	0.111	<0.002
25-5		110-120	0.215	0.155	<0.002
25-7		170-180	0.188	0.125	<0.002
		B-Say-Tah (Echo) Cottage #54			
#28	Between cottage and lake				
28-2		50- 60	0.162	0.80	<0.002

Table 6H

ANALYSIS OF SOIL SAMPLES

Hole #	Distance from Source (metres)	Sample Depth (cms)	Leachate Analysis: Total Extractable Phosphates (% Dry Sample)	Leachate Analysis: Inorganic Phosphates (% Dry sample)	Leachate Analysis: Water Soluble Chlorides (% Dry Sample)
		B-Say-Tah Lagoon (West) Background			
#22	152.4				
22-2		50- 60	0.161	0.750	<0.002
22-7		150-160	0.210	0.190	<0.002
22-10		210-220	0.174	0.155	<0.002
		B-Say-Tah Lagoon (East)			
#21X	152.4X				
21X-2		50- 60	0.174	0.155	<0.002
21X-7		150-160	0.179	0.179	<0.002
21X-9		190-200	0.204	0.149	<0.005
		Lebret Lagoon #2			
#15	152.4				
15-3		50- 60	0.149	0.134	<0.002
15-8		150-160	0.169	0.159	<0.002
15-10		190-200	0.138	0.127	<0.002
		Lebret Lagoon #1			
#17	61.0				
17-2		50- 60	0.195	0.138	<0.002
17-7		150-160	0.162	0.162	<0.002
17-11		230-240	0.176	0.157	<0.012

Table 7A

ANALYSIS OF WATER, SAMPLES, WELLS AND SPRINGS

Location	Sample No.	TPO_4	CL	TOC	TIC	TC	PH	Conductivity	Temp °C	Remarks
				← mg/l →						
Echo Lake (B-Say-Tah)										
Cottage #313	2060	0.18	-	4	98	102	-	1250	10.5	-
	2575	1.90	30	4	83	87	7.8	-	18.0	-
#303	2063	0.26	-	1	85	86	-	-		-
#304	2062	0.26	-	2	79	81	-	1175	12.0	-
# 54	2065	1.42	-	1	115	116	-	3500	9.0	shallow depth about 8 metres
# 54	2570	2.20	269	6	106	112	7.1	-	17.0	-
#	2571	1.50	320	13	109	122	7.7	-	21.0	-
Public Spring	2064	0.18	-	2	107	109	-	3500	8.0	-
	2988	0.33	255	1	114	115	7.6	3500	9.0	-
Fish Hatchery	2067	0.42	-	6	109	115	-	3700	9.9	Depth about 94 metres
	2985	0.24	209	2	105	107	7.66	2900	10.5	
Gordon Place Spring	2070	0.72	-	6	110	116	-	2700	8.5	
Mission Lake										
Lebret Village	2563	0.79	53	1	114	114	7.2	-	16.0	well depth 27 metres

Table 7A (Continued)

Location	Sample No.	TPO_4	CL	TOC	TIC	TC	PH	Conductivity	Temp °C	Remarks
				← mg/l →						
Lebret Training Farm	3456	1.20	58	16	99	115	7.4	2400	6.5	
Harmon Trout farm. Well #1	2986	0.27	9	1	64	64	7.6	890	8.5	depth 39.0 metres
Well #2	2987	9.40	9	1	64	64	7.7	850	7.0	depth 49.0 metres
Pasqua Lake										
Cottage (B.Stone)	2990	0.64	115	1	121	122	7.6	2500	14.5	depth 36.0 metres
Cottage (Schafer)	2991	0.11	122	1	122	123	7.7	2550	11.0	depth 36.0 metres
Cottage (B.Stone) Outside tap	3248	0.32	-	5	115	120	7.5	2500	12.5	
Cottage (B.Stone, Lake discharbe)	3393	0.40	122	2	110	112	7.6	2500	10.0	
Katepwa Lake										
village well	3392	0.24	38	1	82	82	7.3	920	10.0	
Cottage (S.W.Snell)	3455	0.10	28	25	89	114	7.2	1500	11.5	8.4 metres deep
	3457	0.05	49	1	132	133	7.4	2100	7.0	26 metres deep.

Table 7B

ANALYSIS OF WATER SAMPLES, LAKE WATER

Location	Sample No.	TPO_4	CL	TOC	TIC	TC	PH	Conductivity	Temp °C	Remarks
			← mg/l →							
B-Say-Tah										
Shoreline										
Cottage #313 Fri	2061	1.3	-	34	61	95	-	1650	16.0	
4/8 " " "	2447	2.5	87	22	49	71	8.58	-	-	
Front cottage 313	2576	2.5	102	16	54	70	9.6	-	20.0	
Left " "	2577	2.0	99	17	54	71	9.4	-	20.0	
Right " "	2578	1.9	104	16	54	70	9.5	-	20.0	
Point Shoreline										
Front Cottage #54	2066	1.84	-	10	58	68	-	1700	17.5	
" " #54	2433	2.1	90	39	33	72	8.49	-	-	
" " #53	2572	1.7	108	15	54	69	9.3	-	20.0	
" " #54	2573	2.7	105	15	54	69	9.3	-	20.0	
" " #55	2574	2.2	104	11	54	65	9.4	-	20.0	

Table 7C

ANALYSIS OF WATER SAMPLES, LEBRET SEWAGE DISPOSAL SITE

Location	Sample No.	TPO_4	CL	TOC	TIC	TC	pH	Conductivity	Temp	Remarks	
		← mg/l →									
Lagoon #1 South											
surface-30/6	2071	36	-	115	240	355	-	100	17.5		
" -15/9	3052	53.4	170	82	278	360	7.88	2500	17.0		
" -27/10	3396	54.8	184	105	237	342	8.16	2850	8.0		
Hole #7-15/9	2982	0.67	389	27	56	83	7.69	3000	14.0	3 metres 55-65cm	
" "-14/10	3239	0.95	-	150	213	363	7.45	2750	10.0	3 metres	55-65cm
Lagoon #1 North											
surface-30/6	2071	36	-	115	240	355	-	100	17.5		
" -15/9	3052	53.4	160	82	278	360	7.88	2500	17.0		
" -27/10	3396	54.8	184	105	237	342	8.16	2850	8.0		
Hole#29-15/9	2983		495	1	380	380	7.5	3600	14.5	3 metres	14-25cm
" " -14/10	3236		-	37	313	350	7.43	3550	10.5	" "	" " "
" " -27/10	3395		475	36	314	350	8.33	3600	10.0	" "	" " "
Hole#30-15/9	3984		476	12	61	73	7.70	2600	14.5	" "	35-45cm
" " -14/10	3237		-	64	313	377	7.57	3450	10.5	" "	" " "
Hole #1-14/10	3238		-	33	307	340	7.06	3300	10.5	" "	30-100cm
-27/10	3394		376	31	274	305	7.26	3200	10.0	" "	" " "
Lagoon #2 Surface	2436	43	363	175	165	340	8.02	-	-		

Table 7D

ANALYSIS OF WATER SAMPLES, B-SAY-TAH SEWAGE DISPOSAL SITE

Location	Sample No.	TPO_4	CL	TOC	TIC	TC	pH	Conductivity	Temp °C	Remarks
		←———		Mg/l		———→				
Lagoon #1										
Surface	2069	44	-	195	225	420	-	4000	17.5	
"	2445	53	439	270	220	490	8.26	-	-	
" -14/10	3245	50	700	247	313	560	7.91	4700	10.0	
Hole #4-14/10	3243	8.6	560	137	200	337	7.31	3500	9.5	
" "-28/10	3406	6.52	5.10	15	278	293	7.92	3300	8.0	
" #19-14/10	3243	6.6	640	112	175	287	7.34	3750	1-.0	
Lagoon #2										
Surface-28/10	3404	30.6	581	83	187	270	8.44	4800	5.5	

Table 7E

ANALYSIS OF WATER SAMPLES, RAW SEWAGE

Location	Sample No.	TPO_4	CL	TOC	TIC	TC	pH	Conductivity	Temp °C	Remarks
		← mg/l →								
B. Stone-south septic tank-14/10	3246	139	740	480	180	660	7.41	4050	19.5	
" " " " " -27/10	3398	122	281	158	184	342	8.91	3700	20	
" " -north " " cleanout	3397	167	302	142	181	323	7.89	4000	14	27/10
From truck after cleaning septic tank	3247	71	1000	384	206	590	7.88	5200	11	14/10

Table 7F

ANALYSIS OF WATER SAMPLES, PASQUA LAKE COTTAGE

Location	Sample No.	TPO_4	CL	TOC	TIC	TC	pH	Conductivity	Temp °C	Remarks
			← mg/l →							
B. Stone										
well @ pump	2990	0.64	115	1	121	122	7.55	2500	14.5	
well @ outside tap - 14/10	3248	0.32	100	5	115	120	7.53	2500	12.5	
Hole #31-3 metres 0-15cm-15/9	3053	206	91	130	360	490	8.12	4500	20.0	beside septic tank
" " " " " " "-14/10	3241	106	290	226	184	210	7.72	3950	20.0	beside septic tank
" " " " " " "-27/10	3399	169	127	152	248	400	6.95	4000	19.	beside septic tank
septic tank-south cleanout-14/10	3246	139	740	480	180	660	7.41	4050	19.5	
" " " " -27/10	3398	122	281	158	184	342	8.91	3700	20	
septic tank-north cleanout-27/10	3397	167	302	142	181	323	7.89	4000	16	
Hole #42-3 meters 62cm -27/10	3400	167	245	72	270	342	7.79	4000	14	long term seepage

Table 7G

ANALYSIS OF WATER SAMPLES, TOWN AND VILLAGE LAGOONS

Location	Sample No.	TPO_4	CL	TOC	TIC	TC	pH	Conductivity	Temp °C	Remarks
		← mg/l →								
Lebret Village										
Cell #1-surface composite-18/8	2564	9.9	169	26	83	109	8.6	-	23.0	
Cell #2- " " -18/8	2565	8.8	152	17	92	109	8.2	-	23.0	holding
Cell #2-discharge -14/10	3244	5.3	185	23	85	108	8.38	2800	4.5	
Fort Qu'Appelle Town										
North large cell-surface comp. 18/8	2566	17.6	318	38	80	118	8.9	-	21.0	
North large cell-surface comp. 15/9	3054	24.9	323	40	99	130	7.82	2400	16.5	
North large cell-discharge- 18/8	2567	19.0	322	44	85	129	8.3	-	18.0	
North large cell-discharge- 15/9	2989	20.2	311	37	107	144	8.07	2240	17.0	
South cell-surface composite 18/8	2568	11.9	216	48	78	126	8.9	-	22.0	

Table 7H

ANALYSIS OF WATER SAMPLES, VALLEY BOTTOM BACKGROUND

Location	Sample No.	TPO_4	CL	TOC	TIC	TC	pH	Conductivity	Temp °C	Remarks
		← mg/l →								
Hole #46	3401	3.28	160	13	329	342	7.26	3500	9.5	between Echo and Pasqua lakes
#47	3402	0.52	437	17	203	220	7.46	4300	6.5	Ft. Qu'Appelle Lagoon seepage
#48	3405	40.1	143	71	69	140	8.1	2200	6.5	Katepwa village point
#44	3240	0.24	390	12	76	88	7.66	4000	7.0	valley bottom

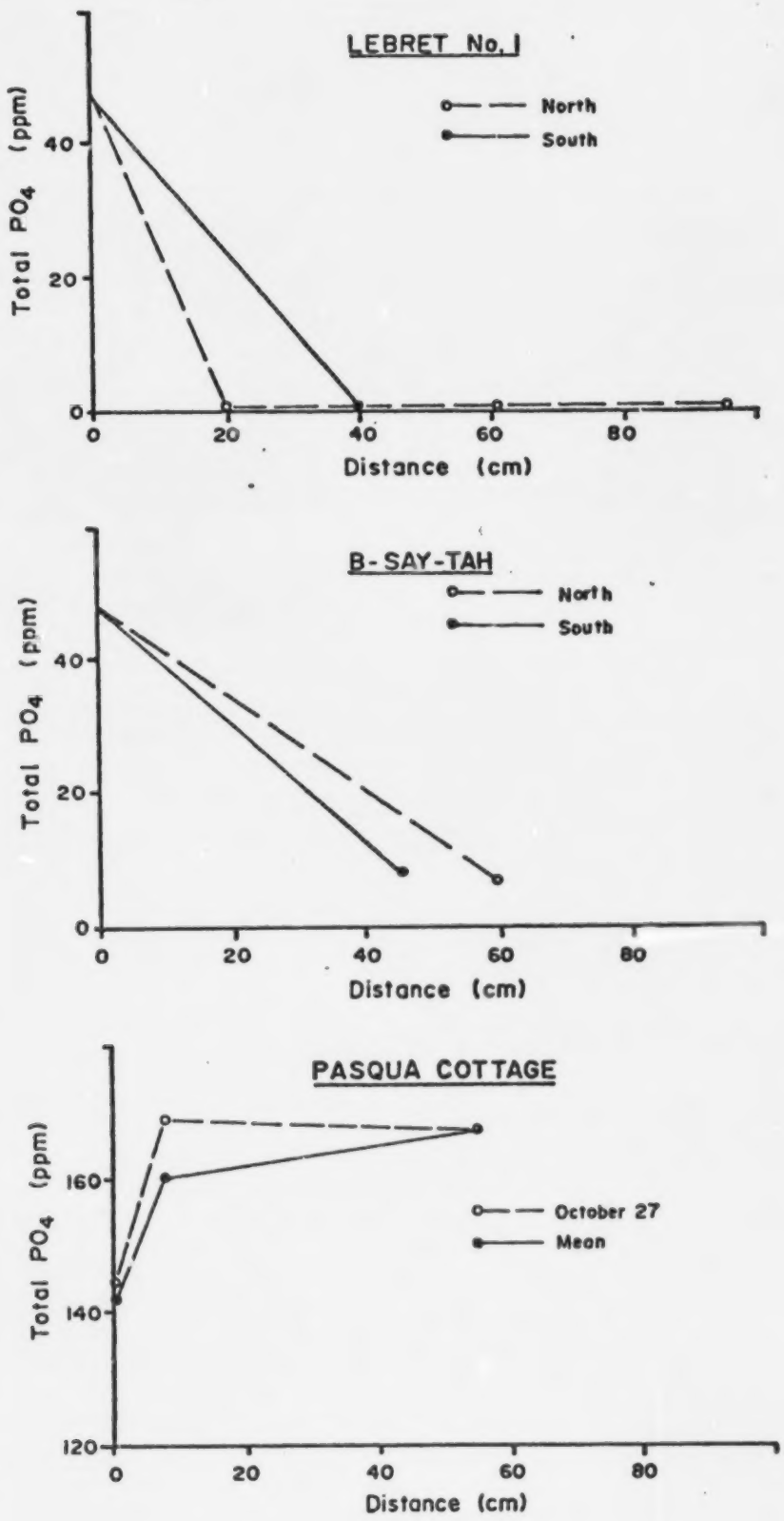
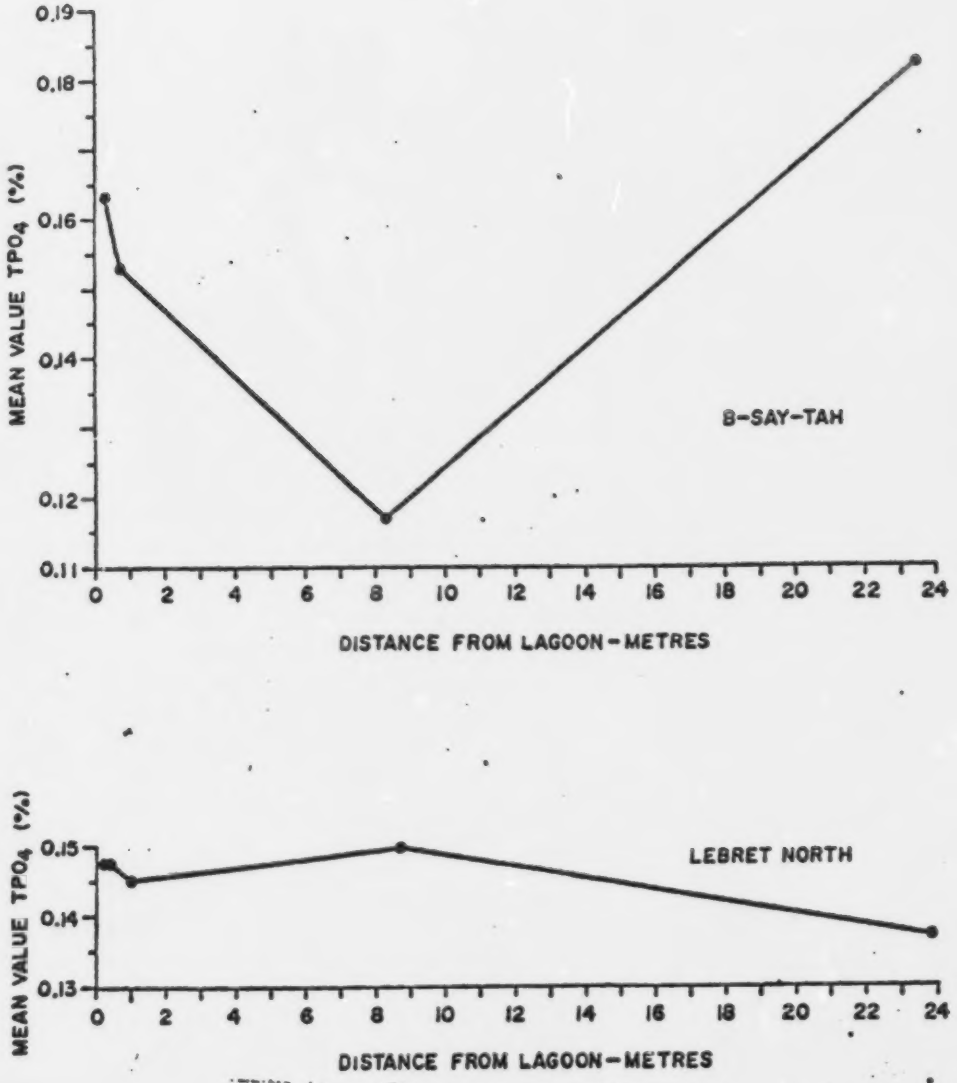


FIG. 8: PHOSPHATE VALUES FROM WATER SAMPLES TAKEN FROM LAGOONS, SEPTIC TANK AND TEST HOLES

bottom are effectively sealed by the sewage sludge. This initial reduction is greater at the Lebret site than at the B-Say-Tah site. In contrast, the seepage samples from test holes at the Pasqua cottage do not show any reduction at all. The phosphates are least affected by transport through soil. Mean value of total phosphates obtained from individual test holes has been plotted as a function of the distance of the test hole from the source, as shown in Fig. 9. The data from the Pasqua cottage show a rapid decrease in the soil retention of phosphates with distance, compared to the other sites. Depth profile of total phosphates and inorganic phosphates are shown in Figs. 10 to 15. From the data given in Tables 5A to 5G and 6A to 6H, the phosphate values do not appear to be well correlated with the lithology of samples. This is not a surprising result as most of the phosphates are retained in the lagoon sidewalls and bottom, and phosphates occur in low concentrations in the subsurface flow, but the situation at the Pasqua and Echo (B-Say-Tah) cottages is quite different. As the septic effluent seeps out of the tanks in both the sites the soils are exposed to high values of phosphates in the subsurface flow. Except in the case of samples with high organic matter (humus) content, the phosphate concentration in the soil leachate does not differ significantly from the background samples. It is emphasized here that factors such as the soil type and moisture regime affect the retention of phosphates in soils and frequent watering of lawns and gardens at the cottages could promote rapid transport of phosphates into the lakes.

To evaluate the percentage adsorption of phosphates within the



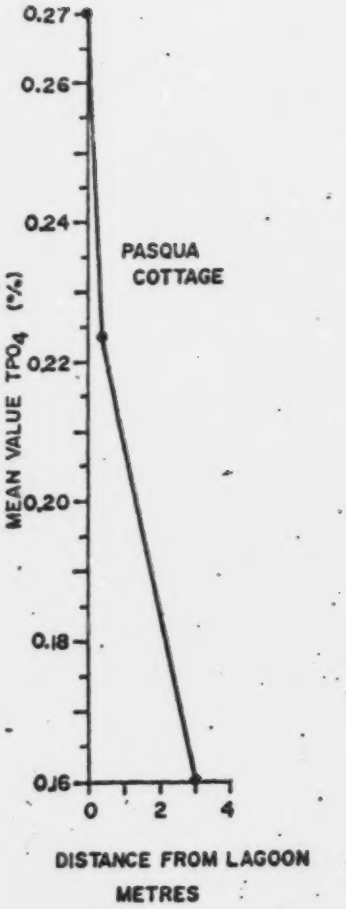


FIG. 9. MEAN VALUES OF TOTAL PHOSPHATES (% ON A DRY MATTER BASIS) FROM TEST HOLES AT THE DISPOSAL SITES AND PASQUA COTTAGE, PLOTTED AS A FUNCTION OF DISTANCE.

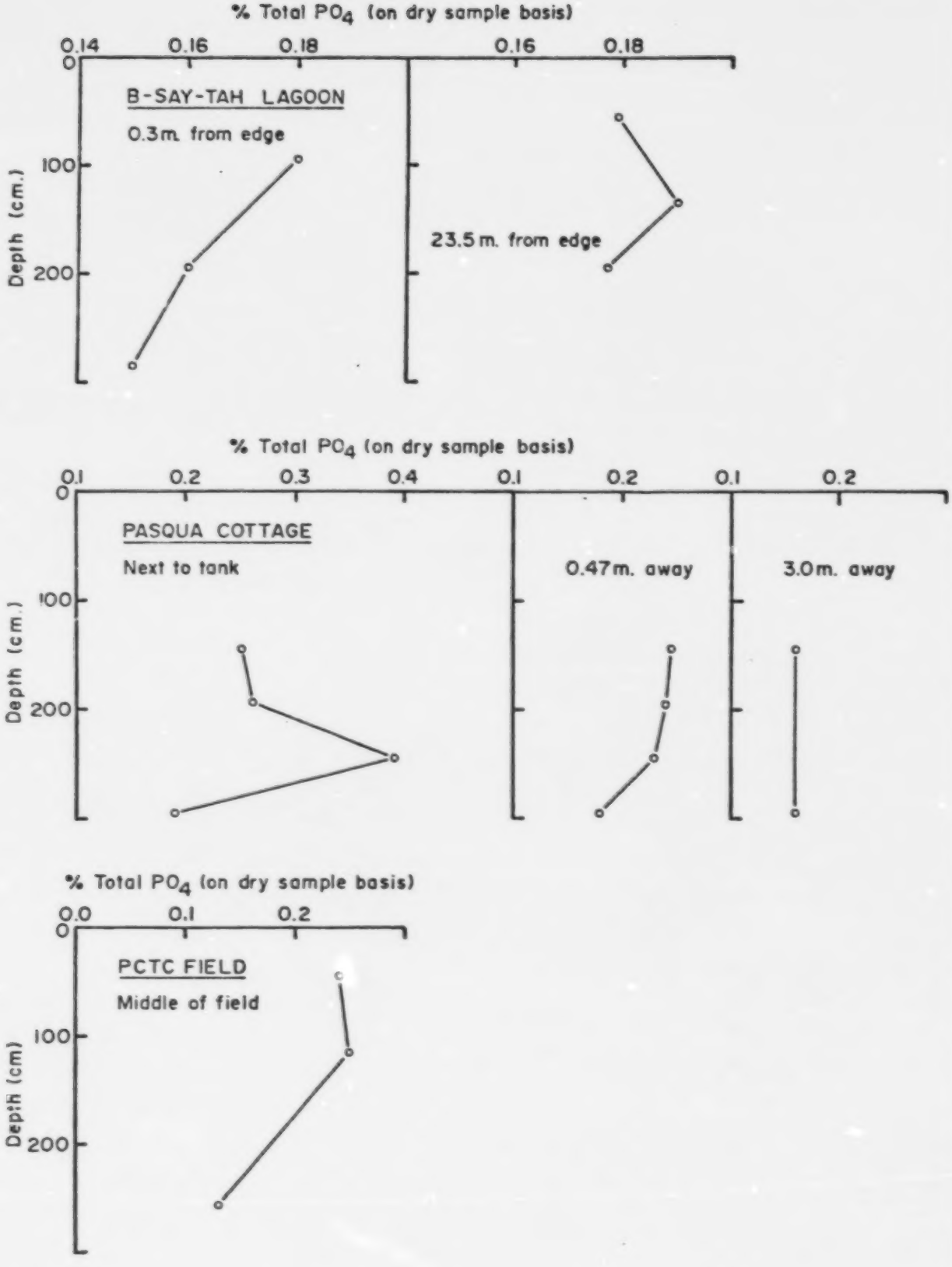


FIG. 10: VERTICAL PROFILE OF TOTAL PHOSPHATES (% DRY SAMPLE) AT VARIOUS TEST HOLES AT THE B-SAY-TAH DISPOSAL SITE, PASQUA COTTAGE AND PCTC FIELD

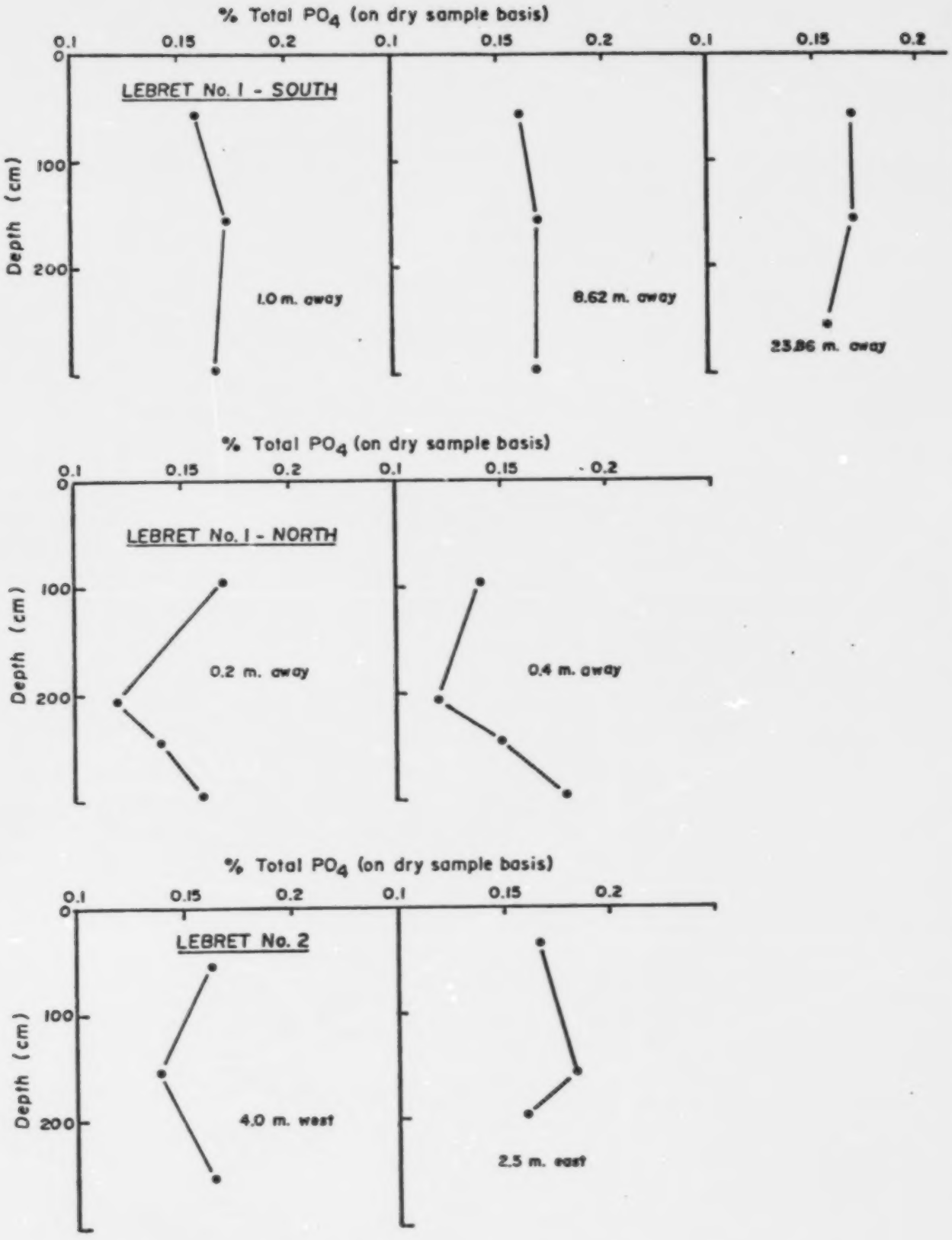


FIG. 11: VERTICAL PROFILES OF TOTAL PHOSPHATES (% DRY SAMPLE BASIS) FROM TEST HOLES AT THE LEBRET SITE

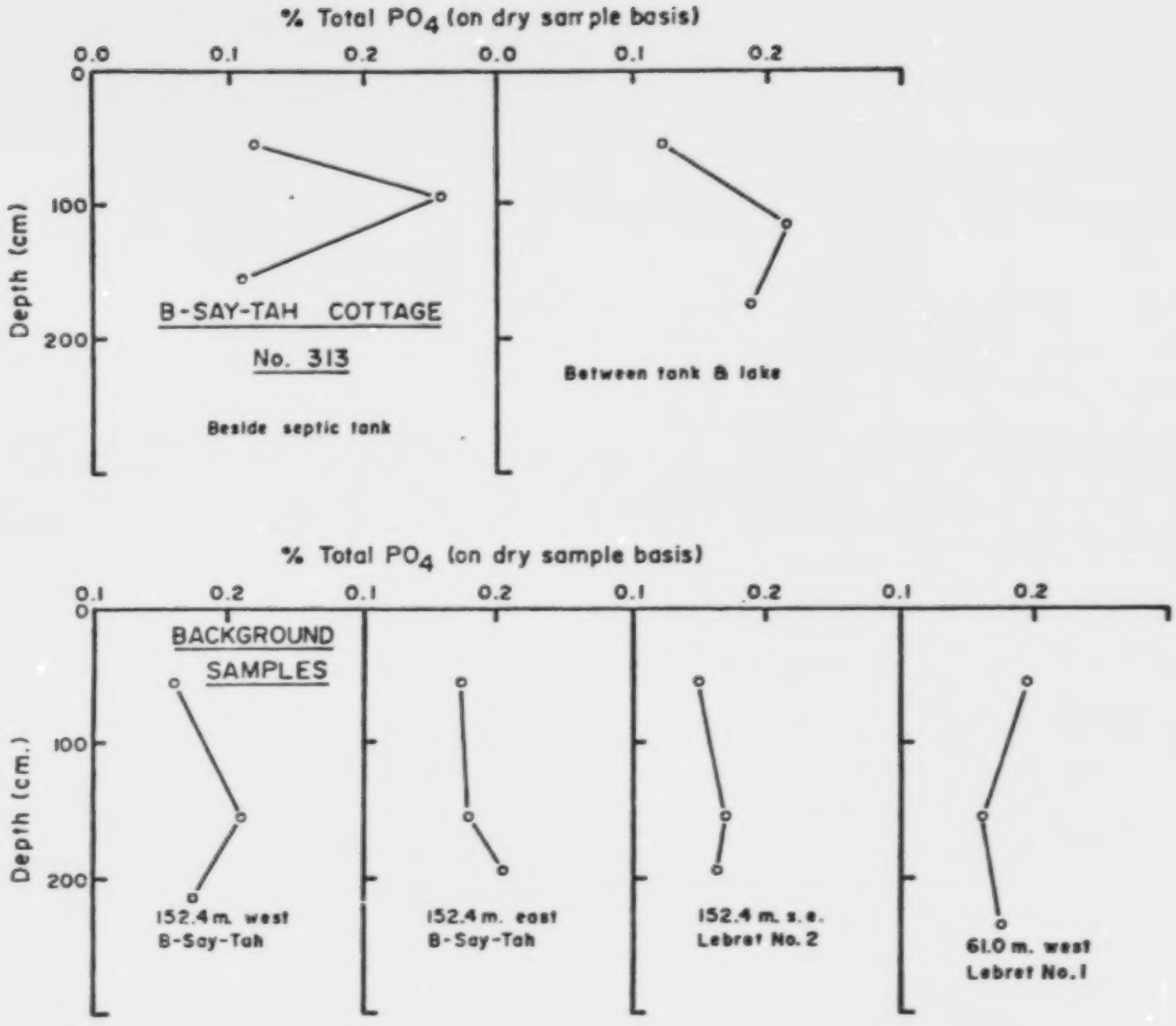


FIG. 12: VERTICAL PROFILES OF TOTAL PHOSPHATES (% DRY SAMPLE BASIS) FROM TEST HOLES AT THE B-SAY-COTTAGE AND BACKGROUND SITES

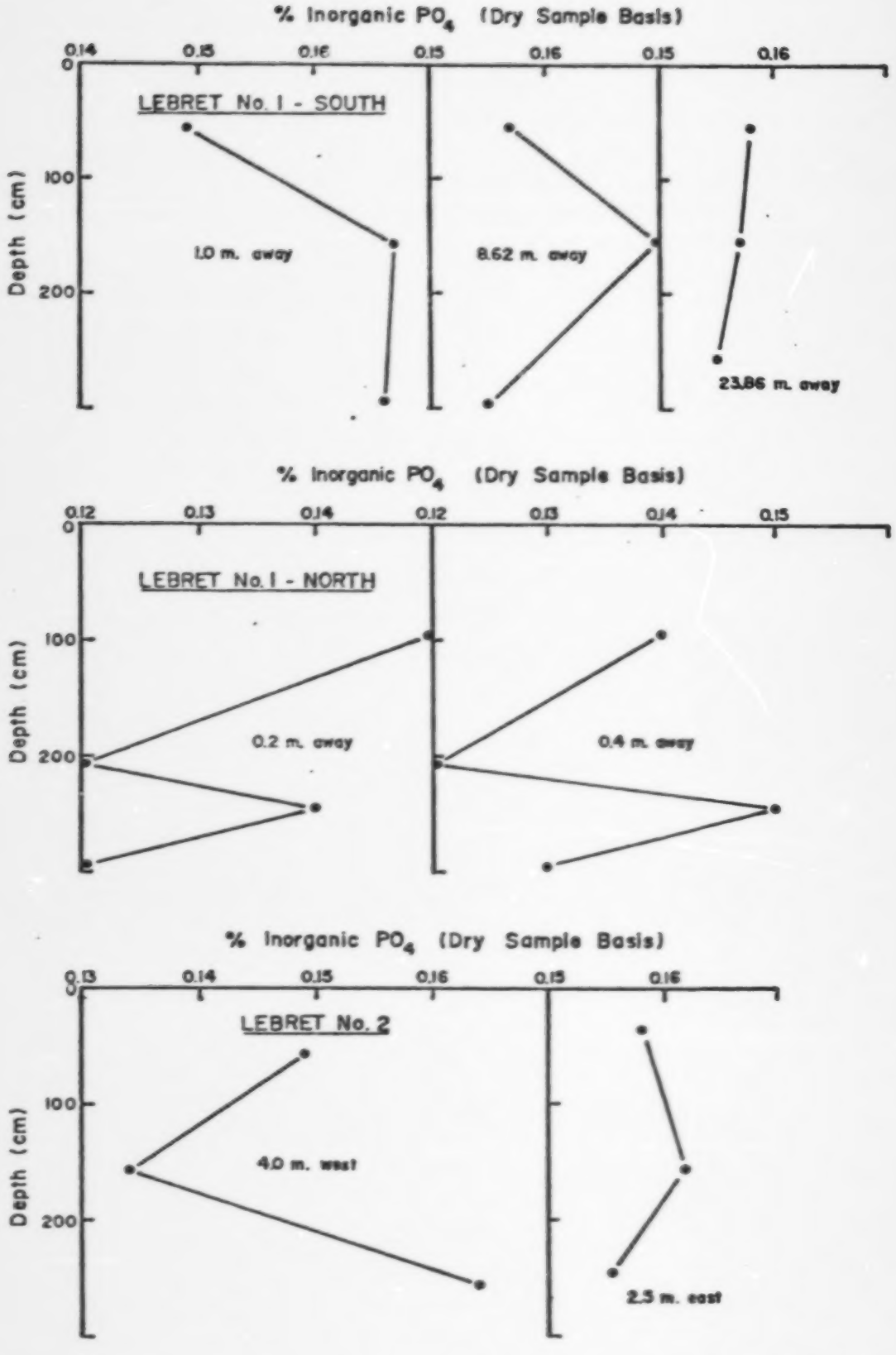


FIG. 13: VERTICAL PROFILES OF % INORGANIC PHOSPHATES FROM TEST HOLES AT THE LEBRET DISPOSAL SITES

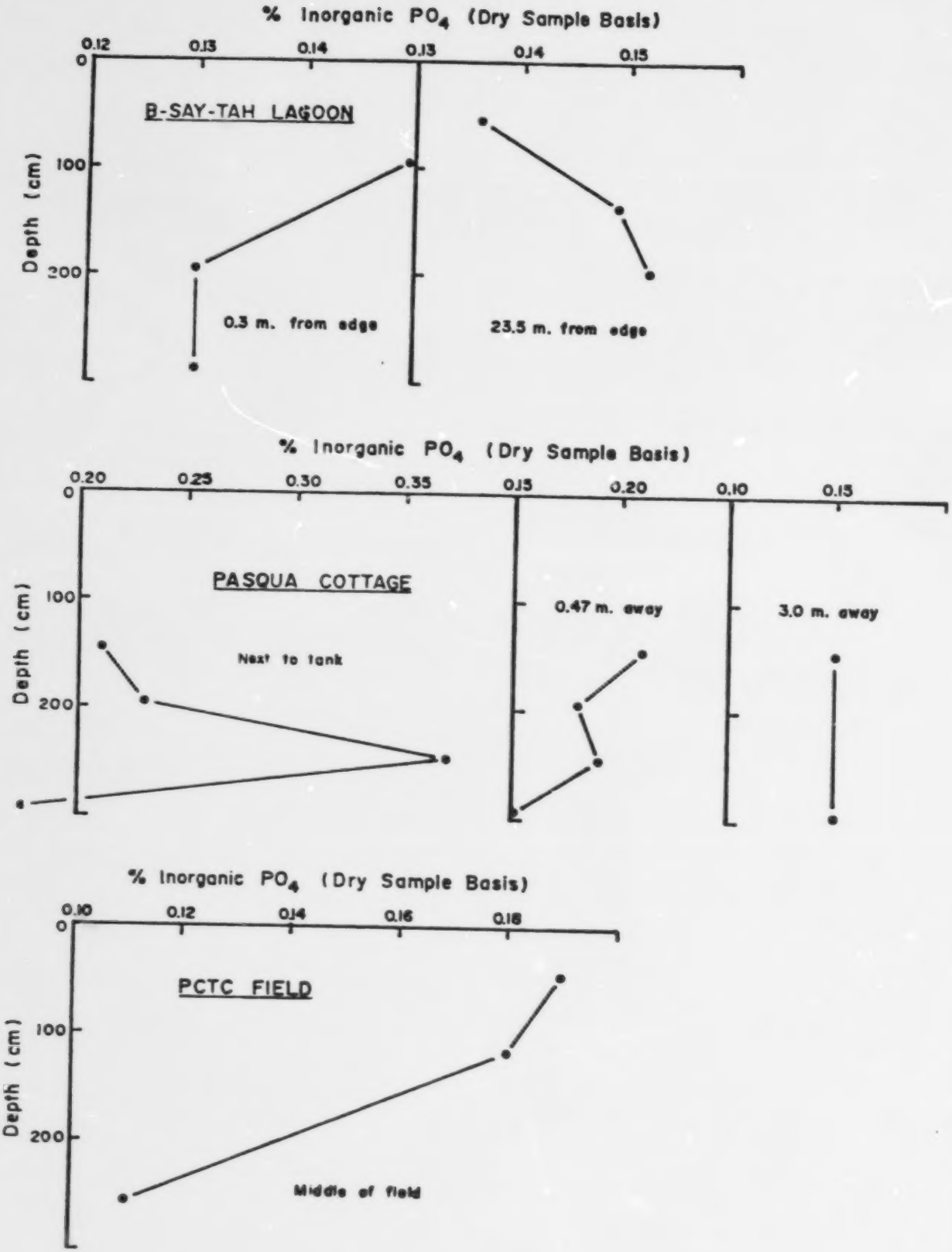


FIG. 14: VERTICAL PROFILES OF % INORGANIC PHOSPHATES FROM TEST HOLES AT THE B-SAY-TAH LAGOON, PASQUA COTTAGE AND PCTC FIELD

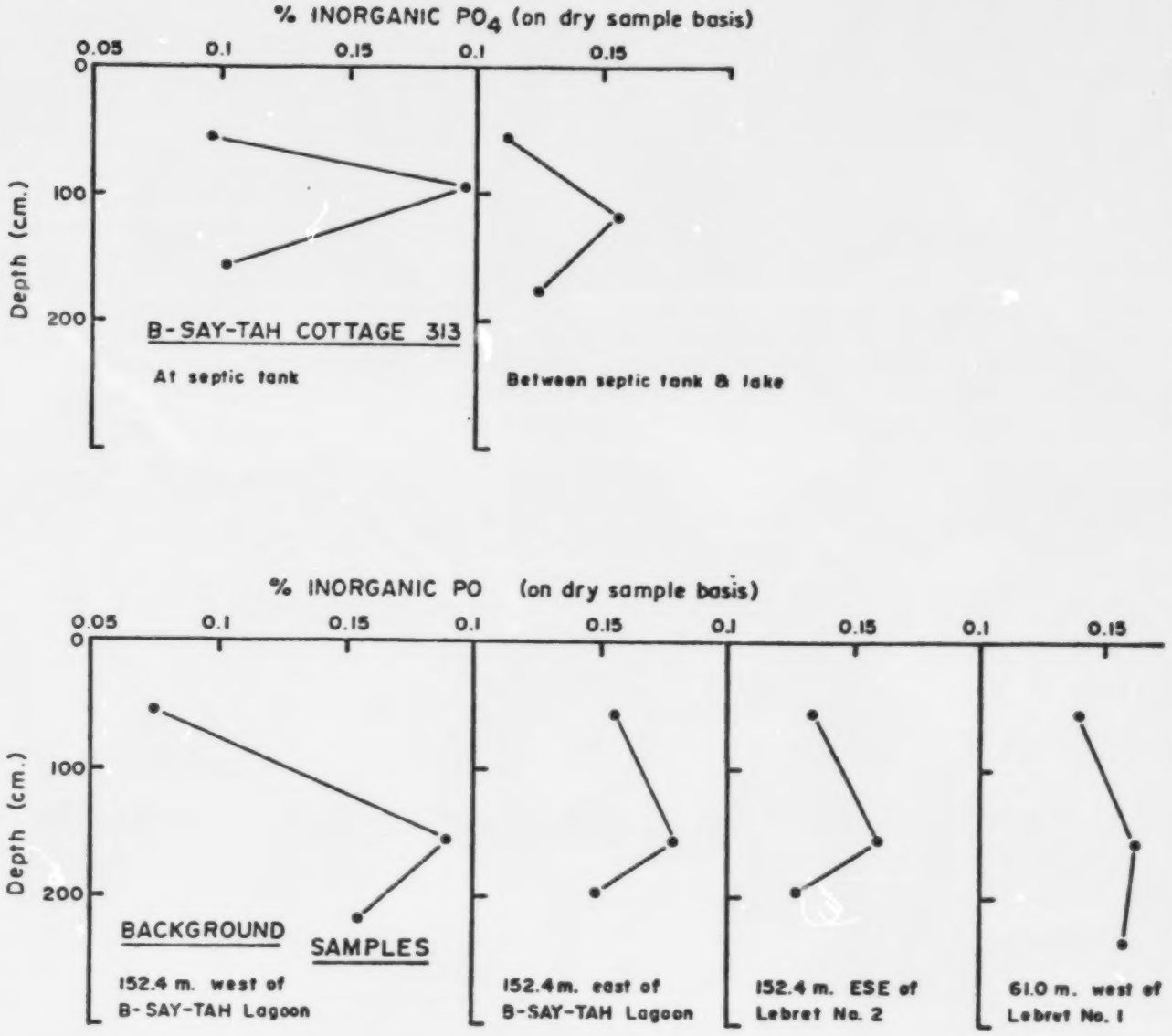


FIG. 15: VERTICAL PROFILES OF % INORGANIC PHOSPHATES FROM TEST HOLES AT THE B-SAY-TAH COTTAGE AND THE BACKGROUND SITES

soil zone, the following procedure has been developed using chlorides as a tracer. Water soluble chlorides are highly mobile and are not adsorbed in soil. This permits their use as a tracer to indicate sewage contamination. Chloride concentration has been used in the following method to provide the dilution factors for estimating the percentage adsorption of phosphates in soils.

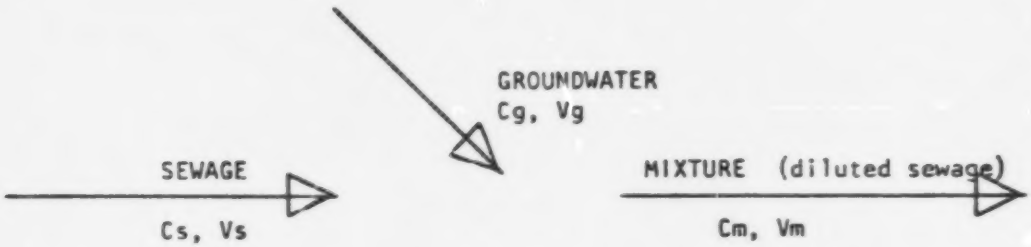
TO DETERMINE THE PERCENTAGE ADSORPTION OF PHOSPHATES IN SOILS

Case a) with groundwater dilution:

Sewage seeping through soil strata is diluted by the influx of groundwater. Let C_s Cg and Cm denote the chloride concentrations in sewage, groundwater and the mixture respectively. Let Vs, Vg and Vm denote their respective volumes of flow. From the following diagram mass and volume budget equations can be written as

$$Cm\ Vm = Cs\ V_S + Cg\ Vg \qquad (1)$$

and $$Vm = Vs + Vg \qquad (2)$$



we define a dilution factor as follows.

$$\text{dilution factor} = \frac{\text{Volume of wastewater}}{\text{Volume of mixture}} = \frac{V_s}{V_m} \qquad (3)$$

combining equation (1) and (2) and using the above definition we have

$$\frac{V_s}{V_m} = \frac{1}{C_s}\left[C_m - C_g\frac{V_g}{V_m}\right] \tag{4}$$

and

$$\frac{V_g}{V_m} = \left(1 - \frac{V_s}{V_m}\right) \tag{5}$$

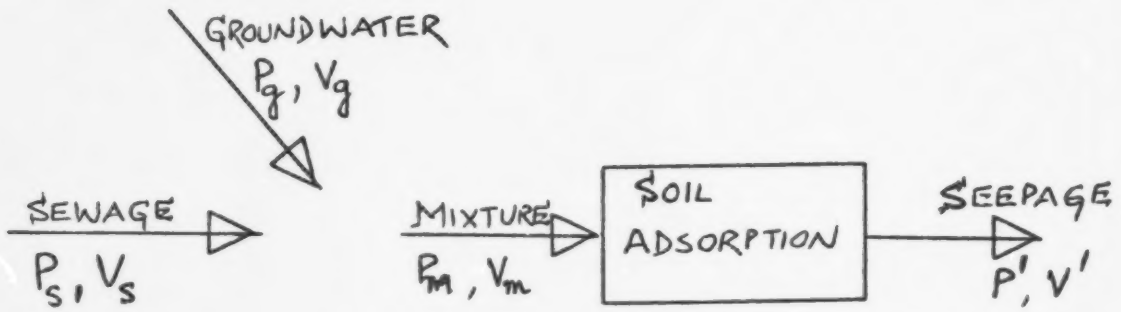
combining (4) and (5) we get:

$$\frac{V_s}{V_m} = \frac{C_m}{C_s} - \frac{C_g}{C_s}\left[1 - \frac{V_s}{V_m}\right]$$

or $$\frac{V_s}{V_m} = \text{DILUTION FACTOR} = \frac{(C_m - C_g)}{(C_s - C_g)} \tag{6}$$

$$= D$$

now, consider the attenuation of phosphorus during the transport of sewage through soil.



Ps, Pg, Pm and P' are the phosphate concentrations in sewage, groundwater, mixture and the seepage sample in test holes. V' is the seepage taken in test holes.

we have

$$P_m V_m = P_s V_s + P_g V_g \tag{7}$$

$$\therefore \quad P_m = \frac{P_s V_s + P_g (V_m - V_s)}{V_m}$$

$$= \frac{V_s (P_s - P_g)}{V_m} + P_g$$

$$= (P_s - P_g) D + P_g \tag{8}$$

percentage removal of phosphorus by soil

$$= \left(1 - \frac{P'}{P_m}\right) 100 = \frac{100\left[(P_s - P_g) D + P_g - P'\right]}{\left[(P_s - P_g) D + P_g\right]} \tag{9}$$

case b) Significant evapotranspiration compared to groundwater influx.

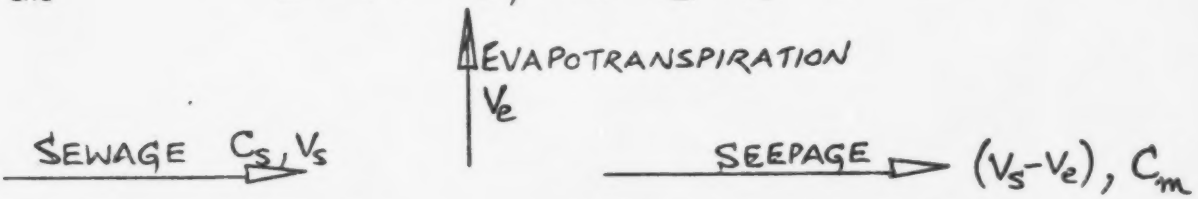
We consider the case where the increase in the solute concentrate due to evaporation is far greater than the effect of dilution from the groundwater flow. This is the case with dry test holes at various distances from the lagoon and shallow depths of flow regime.

It is a simpler situation consisting of only evapotranspiration in the soil zone. Referring to the following flow diagram where V_s and C_s denote the volume flow and concentration of chlorides in the sewage, V_e the evapotranspiration and C_m is the measured chloride concentration in the seepage, we can write the mass and volume budget equation as

$$C_m(V_s - V_e) = C_s V_s \tag{10}$$

and

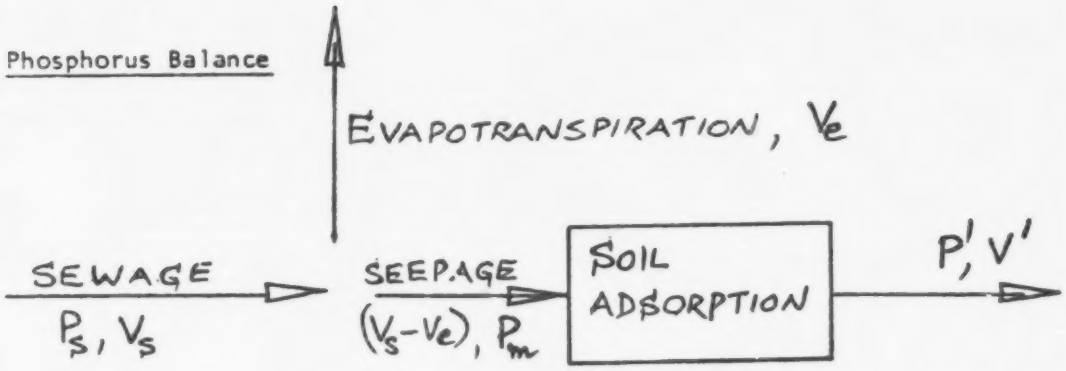
$$V_m = (V_s - V_e), \text{ OR } V_e + V_m = V_s \tag{11}$$



In the above equation, V_m is the volume flow in the seepage combining (10) and (11) we get

$$\frac{C_s}{C_m} = \left(1 - \frac{V_e}{V_m}\right) \tag{12}$$

Phosphorus Balance



p' and V' refer to the concentration of phosphates in a flow volume V' sampled from test holes.

$$P_m(V_s - V_e) = P_s V_s \tag{13}$$

$$P_m = \frac{P_s V_s}{(V_s - V_e)} = \frac{P_s}{\left(1 - \frac{V_e}{V_s}\right)} = P_s\left(\frac{C_m}{C_s}\right) \tag{14}$$

Percentage adsorption of phosphates in soil is

$$A = \frac{100\,(P_m - P')}{P_m} = 100\left[\frac{P_s\,\frac{C_m}{C_s} - P'}{P_s\,(C_m/C_s)}\right]$$

$$= 100\left[1 - \frac{P'C_s}{P_s C_m}\right] \tag{15}$$

Considering the values obtained from test holes for chloride and phosphate concentrations case b) appears to be more applicable than case a).

Percentage adsorption in soils has been computed using the field data from Lebret and B-Say-Tah and are given in Table 8.

Table 8

PERCENTAGE ADSORPTION OF PHOSPHATES IN THE SOIL ZONE

(P_s =Phosphate concentration in sewage: P'=phosphate concentration in test hole; cm-chloride concentration in test hole C_s=shloride concentration in sewage).

Hole	Distance from lagoon	P_s	P^1	C_m	C_s	Percentage adsorption of phosphates
		SITE, LEBRET LAGOON #1 NORTH SIDE				
29	19	54.1	0.57	485	177	99.6
30	40	54.1	0.75	476	177	99.5
1	100	54.1	0.43	576	177	99.8
		SITE, B-SAY-TAH LAGOON				
4(west)	75	50.0	8.6	560	700	85.0
19(east)	100	50.00	6.6	640	700	85.6

The values for Pasqua cottage are not shown as the adsorption values are negative.

Attenuation in the phosphorus concentration due to adsorption in soils is significant at both the sewage disposal sites. Studies done in Ontario suggest similar behaviour and have shown that the lagoon bottoms completely and the side walls to a lesser degree are sealed by the sludge, thereby minimizing the seepage out of the lagoon (ref. 19). Applying similar procedure to the test holes at the Pasqua cottage did

not indicate any reduction in the phosphorus levels due to soil. Probably this could be due to the presence of light sandy soil in the area where sorption capacity for phosphorus is low. The application of the procedure to evaluate phosphorus sorption in soils is limited to test holes from which seepage samples have been collected.

Mean and standard deviations of total phosphorus and inorganic phosphorus for various sites are given in Table 9. The background samples do not differ significantly from the samples from the disposal sites in total and inorganic phosphates. Pasqua cottage which is known to have a leaking septic tank and the tile field at PCTC show high values of total phosphates and inorganic phosphates compared to the other sites. It is clear from Table 9 that the sidewalls and the bottom of the disposal lagoons are effectively sealed by the sludge reducing the transport of phosphates into the seepage field. The sandy soil generally exists in the shoreline areas and the high moisture content because of frequent watering of lawns and gardens could cause relatively rapid transport of phosphates into the lake and well waters. The direct pollution from leaking septic tanks may cause concern in view of their close proximity to the lakes and undesirable soil properties. A compensating factor in this regard is the small number of cottages with leaking septic tanks as estimated in Table 2. Again, this number is an estimate and has been obtained from long and detailed lists of cottages, and the information gathered from interviews and discussions.

It should be mentioned here that the provincial Department of Health carries out occasional well sampling to determine the total coliform counts and nitrates. Although high total coliform counts do not necessarily

Table 9

SOIL LEACHATE VALUES

Site	Mean TPO_4 mg/l	STD Dev^n	Sample	Mean Inorg TPO_4	Sd Dev	N
Lebret lagoon #1 South	1618	69	9	1593	68	9
Lebret lagoon #1 North	1449	172	25	1337	130	8
Lebret lagoon #2	1628	147	6	1538	110	6
B-Say-Tah lagoon west	1510	332	15	1412	103	6
B. Stone (Pasqua) cottage	2295	683	10	2010	657	10
PCTC field	2067	666	3	1600	436	3
B-Say-Tah cottage	1687	603	7	1307	384	7
Background samples	1742	212	12	1483	290	12

indicate fecal contamination they should be viewed seriously whenever they occur in cottage wells situated close to the septic tanks. Saskatchewan's suggested standards for surface waters are a count of 5,000 per 100 ml of sample for coliforms and a count of 1,000 per 100 ml of sample for fecal coliforms. For drinking water such as well water in cottages the most probable number for coliforms should not exceed 10 ml per 100 ml of sample or 3 per 100 ml if membrane filter method is used. Extensive information was obtained from the Department of Health, Regina on the cottage water inventory for the years 1974 to 1977, and these have been put on large maps for identifying the cottages or areas with high coliform counts which should probably indicate the presence of leaking septic tanks. These are given separately in Appendix B. Table 10 summarizes the number of cottages where the wells were found to contain coliform counts in the categories, a) greater than 10 but less than 100, and b) greater than 100. This inventory was carried out over the years in Pasqua, Echo and Ketepwa areas and it is not known how extensive the survey was in terms of coverage in each lake area. It is presumed from our discussion with the public health personnel that the survey was aimed at particular sections of the shoreline where fecal contamination was suspected. Since the completion of the survey some of the cottages with undesirable water quality have improved their septic tanks.

To provide an overview of the situation the following flow diagram, Fig. 16, has been prepared to indicate the significance of various sources of phosphate contribution. The numbers in each box represent the mean phosphate concentrations computed from the field data for individual

Table 10

COLIFORM COUNTS IN WELL WATER

(Limited survey conducted by the Department of Health)

Lake	Measured Coliform Counts	
	Greated than 10 but less than 100 (per 100 ml sample)	Greater than 100 (Per 100 ml sample)
Pasqua	2	8
Echo (village of Katepwa)	7	10
Echo	3	4
Katepwa	29	23
Total	41	45

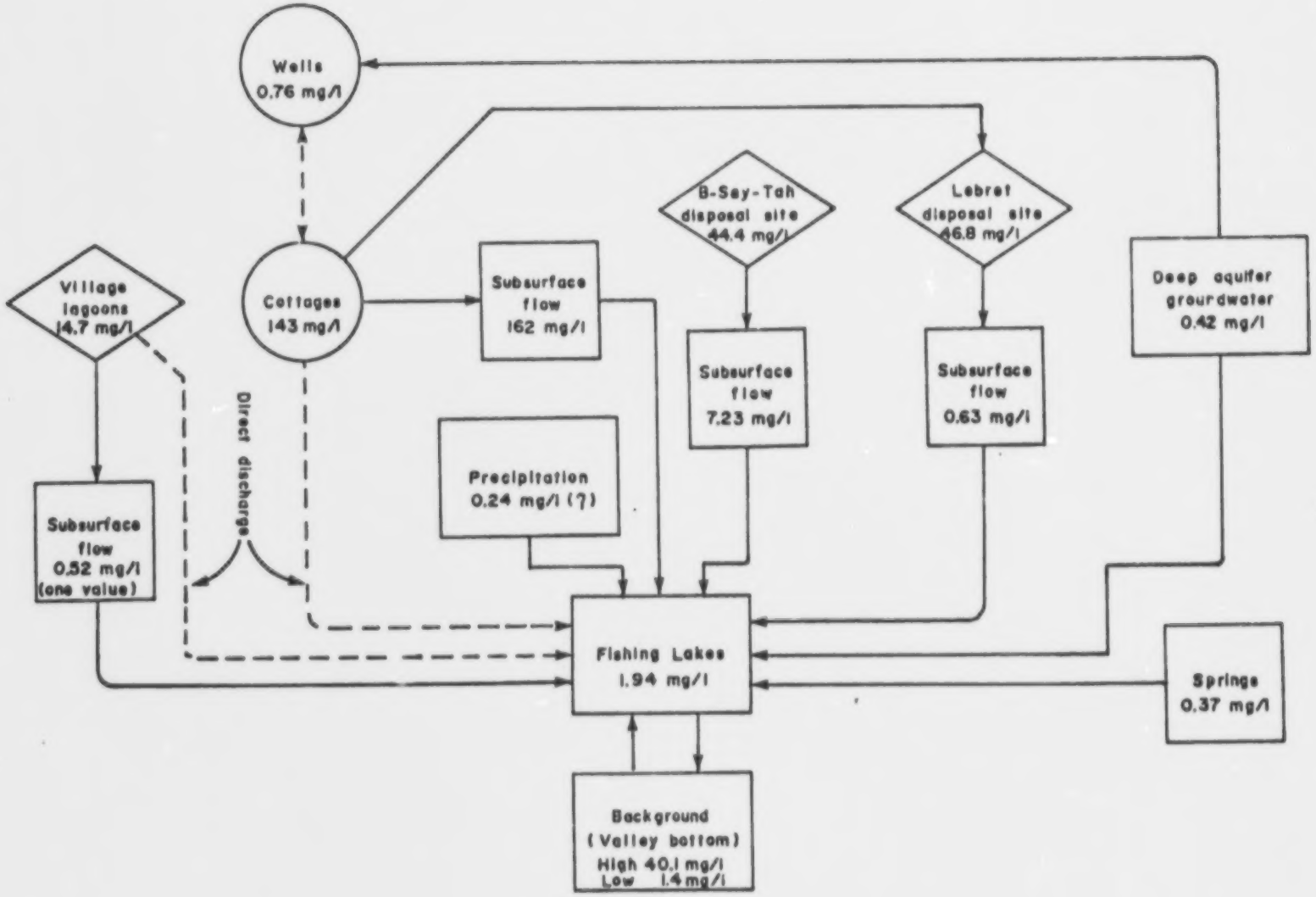


FIG. 16: PATHWAYS OF PHOSPHATES TO THE FISHING LAKES FROM SOME OF THE SOURCES CONSIDERED IN THIS STUDY. MEAN CONCENTRATIONS ARE INDICATED IN THE BOXES.

sources and indicate the relative magnitude of the contributions. Water samples from test holes at the Pasqua cottage and the two disposal sites are used to indicate the magnitude of sub surface flow. Groundwater data from deep wells are taken from the SRC-well log files. Among the background samples obtained from the valley bottom the sample taken at test hole #48, Katepwa Village Point is quite high in phosphates at 40.1 mg/l. For lack of supporting data regarding the reliability of this value it has been singled out in the flow sheet. The tables following the diagram summarize the data used in computing the means. The disposal site at the village of Katepwa is not included in the diagram for lack of water sample data. The value for the input from direct precipitation is taken from reference 14, a recent study done in Alberta.

Table 11

(Data used in Figure 16)

SOURCE	TPO_4 mg/l	MEAN TPO_4 mg/l	SAMPLE #	LOCATION
VILLAGE LAGOONS	9.9		2564	LEBRET VILLAGE CELL# 1
	8.8		2565	LEBRET VILLAGE CELL#2
	5.3		3244	LEBRET VILLAGE CELL# 2 (discharge)
	17.6		2566	FT.QU'APPELLE NORTH LARGE CELL
	24.9		3054	FT.QU'APPELLE NORTH CELL
	19.0		2567	FT.QU'APPELLE LARGE CELL (DISCHARGE)
	20.2		2989	FT.QU'APPELLE LARGE CELL (DISCHARGE)
	11.9		2568	SOUTH CELL
		14.7		
SEWAGE DISPOSAL SITES	36.0		2071	LEBRET LAGOON #1
	53.4		3052	LEBRET LAGOON #1
	54.8		3396	LEBRET LAGOON #1
	43.0		2436	LEBRET LAGOON #2
	44.0		2069	B-SAY-TAH LAGOON #1
	53.0		2445	B-SAY-TAH LAGOON #1
	50.0		3245	B-SAY-TAH LAGOON #1
	30.6		3404	B-SAY-TAH LAGOON #2
		46.8 (LEBRET); 44.4 (B-SAY-TAH)		

Table 11

(Data used in Figure 16)

SOURCE	TPO_4 mg/l	MEAN TPO_4 mg/l	SAMPLE #	LOCATION
COTTAGE WELLS	0.18		2060	COTTAGE #313B
	0.26		2063	COTTAGE #303B
	2.20		2570	COTTAGE #54B
	1.50		2571	COTTAGE # 55 B
	1.90		2575	COTTAGE #313 E
	0.64		2990	PASQUA COTTAGE (PUMP)
	0.11		2991	SCHAFFER COTTAGE
	0.32		3248	PASQUA COTTAGE (TAP)
	0.40		3393	PASQUA COTTAGE FLOWING WELL
	0.10		3455	S.W.SNELL COTTAGE (SHALLOW WELL)
	0.043		3457	S.W.SNELL (DEEP WELL)
	1.42		2065	COTTAGE # 54 B
		0.76		
DEEP AQUIFER WELLS	0.42		2067	FISH HATCHERY
	0.79		2563	LEBRET VILLAGE
	0.24		2985	FISH HATCHERY
	0.27		2986	HARMAN TROUT FARM# 1
	0.40		2987	HARMAN TROUT FARM #2
	0.64		2990	PASQUA COTTAGE (PUMP)

Table 11

(Data used in Figure 16)

SOURCE	TPO_4 mg/l	MEAN TPO_4 mg/l	SAMPLE #	LOCATION
DEEP AQUIFER WELLS (CONTD)	0.11		2091	SCHAFER COTTAGE
	0.32		3248	PASQUA COTTAGE (TAP)
	0.24		3392	KATEPWA VILLAGE
	0.40		3393	PASQUA FLOWING WELL
	1.20		3456	LEBRET TEAINING FARM
	0.048		3457	S.W.SNELL (DEEP WELL)
		0.42		
FISHING LAKES	1.05		A1509	ECHO LAKE
	1.54		A2441	ECHO LAKE
	1.30		2061	COTTAGE 313 B- FRONT
	1.84		2066	COTTAGE 52 B - FRONT
	1.70		2572	COTTAGE 53 B -- FRONT
	2.10		2443	COTTAGE 54B --FRONT
	2.50		2447	COTTAGE 313 B--FRONT
	2.70		2573	COTTAGE 54 B--FRONT
	2.20		2574	COTTAGE 55 B -- FRONT
	2.50		2576	COTTAGE 313 E--FRONT
	2.00		2577	COTTAGE 313 E--FRONT
	1.90		2578	COTTAGE 313 E--FRONT
		1.94		

Table 11

(Data used in Figure 16)

SOURCE	TPO_4 mg/l	MEAN TPO_4 mg/l	SAMPLE #	LOCATION
SPRINGS	0.26			COTTAGE # 304
	0.18			B_SAY-TAH PUBLIC SPRING
	0.33			B-SAY-TAH PUBLIC SPRING
	0.72			ECHO LAKE GORDON PLACE
		0.37		
SUB-SURFACE FLOW FROM COTTAGES	206.0		3053	PASQUA COTTAGE
	106.0		3241	PASQUA COTTAGE
	169.0		3399	PASQUA COTTAGE
	167.0		3400	PASQUA COTTAGE
		162.0		
SUB-SURFACE FLOW FROM DISPOSAL SITES. B-SAY-TAH SITE	8.60		3242	
	6.50		3406	
	6.60		3243	
		7.23		
LEBRET SITE	0.67		2982	
	0.95		3239	
	0.75		2983	

Table 11

(Data used in Figure 16)

SOURCE	TPO_4 mg/l	MEAN TPO_4 mg/l	SAMPLE #	LOCATION
LEBRET SITE (CONTD)	0.44		3236	
	0.52		3395	
	0.31		2984	
	0.58		3237	
	0.38		3238	
	0.48		3394	
		0.63		
FROM DIRECT PRECIPITATION. SEE REFERENCE #14				
	0.24			
Septic Effluent	139.0		3246	Pasqua
from cottages	122.0		3398	cottage
			3397	septic tank
Sub surface flow	0.52		3402	lagoon
village lagoon				seepage
(Fr. Qu'Appelle)				

PHOSPHATE CONTRIBUTION FROM SOME MAJOR SOURCES TO THE FISHING LAKES.

The following table presents estimates of phosphate contribution from village lagoons, sewage disposal lagoons, cottages, deep aquifers and some point discharges into the Fishing Lakes. It should be emphasized that these quantities are not accurate but only estimates derived from measured data as well as from several assumptions. For example, while the number of cottages suspected of discharging directly into the Fishing Lakes is obtained from numerous records and field work the actual quantity of phosphates contributed from each cottage is based on the following assumptions.

Average occupancy in each cottage = 3 persons

Period of occupancy = 120 days

Phosphate excretion data given by the EPA Manual is modified to reflect the seasonal aspect of the cottages. (Ref.20)

The flow diagram giving the various quantities of PO_4-P is expected to indicate the relative magnitudes of various contributions.

The estimate for the contribution from the Hatfield Valley Aquifer applies to the entire Qu'Appelle River System from Pasqua to the Saskatchewan-Manitoba border. And the estimate for the direct precipitation is based on a gross water surface area of 250 square miles for the Qu'Appelle River.

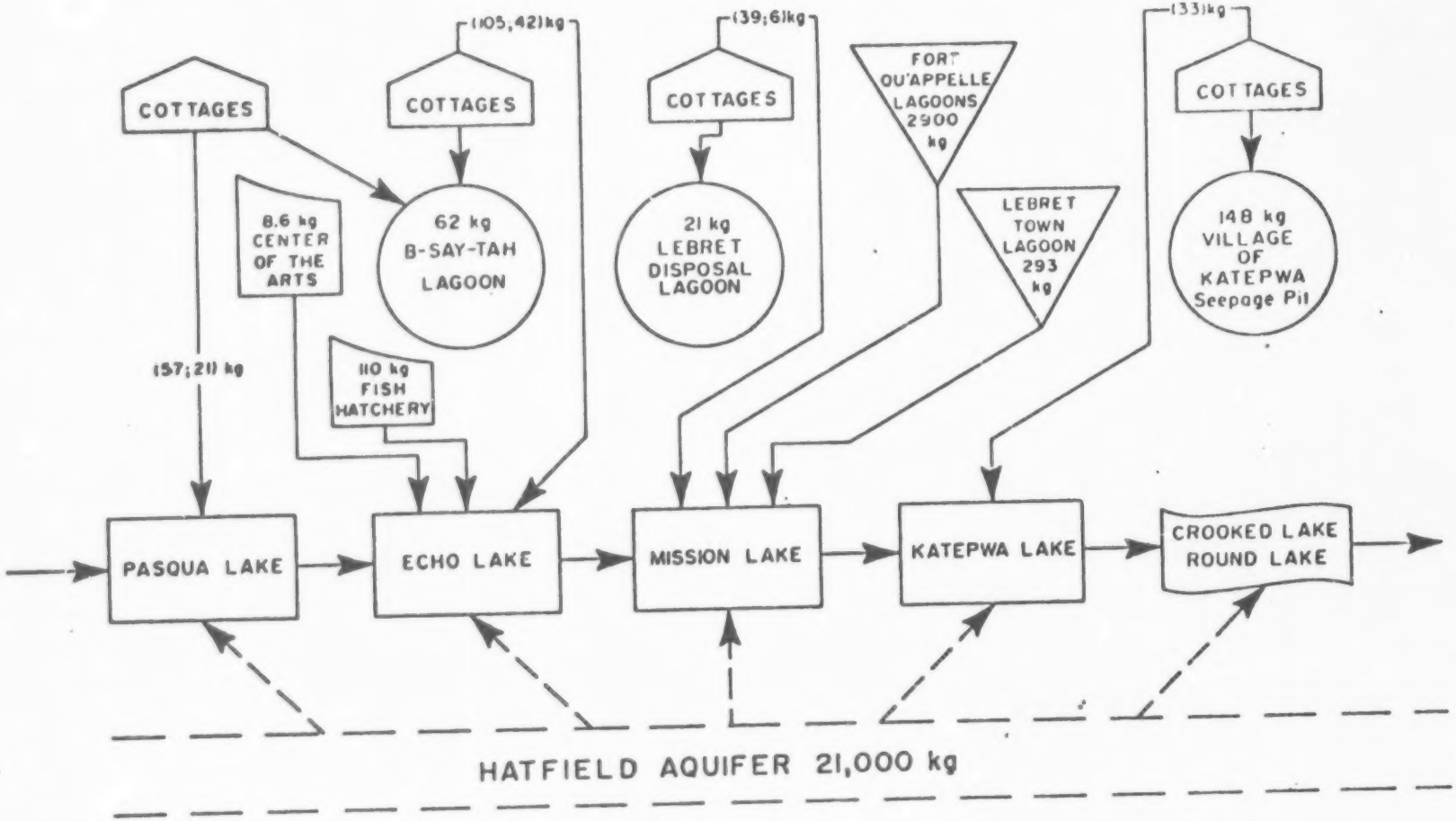


FIG.17. ESTIMATED PHOSPHATE CONTRIBUTION TO THE QU'APPELLE RIVER SYSTEM FROM VARIOUS POINT DISCHARGES AND THE GROUNDWATER. DIRECT DISCHARGES FROM COTTAGES SHOWN IN PARENTHESIS INDICATE THE MAXIMUM AND MINIMUM ESTIMATES RESPECTIVELY. ONLY THE MINIMUM VALUE IS SHOWN FOR KATEPWA.

TABLE 12

PHOSPHATE CONTRIBUTION FROM SOME MAJOR SOURCES INTO THE FISHING LAKES

Source	Lake	Annual Contribution (PO_4-P) Kg	Remarks
Direct Discharge[1]* from Cottages	PASQUA	57.0	maximum
		21.0	minimum
	ECHO	105.0	maximum
		42.0	minimum
	MISSION	39.0	maximum
		6.0	minimum
	KATEPWA	33.0	minimum
B-Say-Tah[2] Septic Disposal Lagoon		62.0	not discharged
Fish Hatchery[3]	ECHO	110.0	
Echo Valley[4] Centre of the Arts	ECHO	8.6	
Ft. Qu'Appelle[5]	MISSION	2,900.0	Based on EPA value this could be 8,660.0 Kg
Lebret (Village)[6]	MISSION	293.0	Based on EPA value this could be 1,892.0 Kg
Lebret Septic[7] Disposal Lagoon		21.0	not discharged
Village of[8] Katepwa Seepage Pit		148.0	not discharged
Hatfield Valley[9] Aquifer	TO THE QU'APPELLE R. SYSTEM	21,000.0	Reference 20
Direct[10] Precipitation	TO THE QU'APPELLE R. SYSTEM	57,000.0	Reference 14

* Numbers refer to the resource data.

RESOURCE DATA FOR TABLE 12

1) Cottages:

Based on a mean annual contribution of PO_4-P = 10.5 lb/capita.

Average number of occupants = 3 persons/cottage.

Duration of occupancy = 120 days

2) B-Say-Tah Disposal Site:

Area = 16,900 ft^2

Depth = 3 ft.

Volume = 5.1×10^4 cft

= 1.4×10^6 litres

Mean PO_4-P concentration = 44.4 mg/L

3) Fish Hatchery

Rate of discharge = 200 gallons per minute

Mean PO_4-P concentration = 0.23 mg/L

4) Echo Valley Centre of the Arts:

Mean yearly discharge = 1.14×10^6 litres

Mean PO_4-P concentration = 7.6 mg/L

5) Fort Qu'Appelle:

Population = 1,831 (1976 data)

a) Average sewage volume = 50 gallons per day per capita

Total volume = 1.52×10^8 litres per year

Mean PO_4-P concentration = 19.1 mg/L

b) Based on EPA value of 10.5 lb/capita/year, total PO_4-P loading would be = 8,660.0 Kg

6) Lebret Village:

Population = 300 residents

Sewage production = 2.5×10^7 litres/year

a) And, Indian school, 220 students. Average sewage production = 20 gallons/capita/day

Mean PO_4-P concentration = 10.1 mg/L

..../2

RESOURCE DATA FOR TABLE 12 (continued)

6) b) Based on the EPA value, PO_4-P loading would be approximately 1,892.0 Kg

7) Lebret Septic Disposal Site:

Area	= 4,000 ft^2
Depth	= 4 ft
Volume	= 4.5×10^5 litres
Mean PO_4-P concentration	= 46.8 mg/L

8) Village of Katepwa:

Sewage disposal	= 10 loads/day
Frequency	= 3 days/week
Capacity	= 1,000 gallons/load
Approximate duration	= 6 months
Total volume disposed	= 3.3×10^6 litres
Mean PO_4-P concentration	= 45.0 mg/L

9) Hatfield Aquifer:

Annual flow into the Qu'Appelle River system
= 40,000 acre-ft
= 4.9×10^{10} litres

Mean PO_4-P concentration = 0.42 mg/L

10) Direct Precipitation:

Approximate surface area of the river system
= 250 square miles
= 6.5×10^8 m^2

PO_4-P concentration in the precipitation
= 87 mg per square metre

CONCLUSIONS

1) Approximately 50% of the total number of cottages on Pasqua, Echo, Mission and Katepwa are regularly serviced by Fort Septic Services and Pantel Plumbing and Heating Ltd., both operating from Fort Qu'Appelle. The Village of Katepwa services most of the cottages in the village. The actual figures could be in excess of the above as most transactions are not documented.

2) Most of the effluent from cottages is pumped into the disposal sites at Lebret and B-Say-Tah. In addition, there are several farm sites where the septic effluent is occassionally disposed of.

3) The effluents from parks, centres of training and recreation, fish hatchery and institutions end up in the fishing lakes with or without any preliminary treatment. Parks operate their own lagoons. The Echo Valley Centre has a primary treatment and chlorination facility.

4) The disposal sites at Lebret and B-Say-Tah where the bulk of the cottage effluents is discharged regularly are reasonably located because of their distance from the lakes and the significant adsorption in the soil zone. The sidewalls and the lagoon bottoms appear to be effectively sealed by the sewage sludge.

Soil leachate data from disposal sites are indistinguishable from the background values obtained from the sites in the valley bottom or the general vicinity of the disposal area.

5) The test hole data form 'Pasqua Cottage' and the 'B-Say-Tah cottage' indicate that phosphates from the leaking septic systems are poorly adsorbed by the soil. Soil characteristics and high moisture content in these areas preclude effective contanment of leaking septic tank

effluent within the soil strata. The cottages with such problems do pose a threat to the quality of well and lake waters.

6) From the survey done during the present study it is estimated that there are about 2 per cent of the total number of cottages that may be contributing phosphates to the lakes. But the well water quality survey conducted by the Department of Health from 1974 to 1977 although limited in its coverage, suggests that this figure may be as high as 6 per cent of the total. According to this survey there are about 41 cottages where the well water reaches a coliform count of more than 10 but less than 100 and about 45 cottages where the coliform count is more than 100. (in a standard sample volume of 100 mls).

7) From the test hole data in the disposal areas, the contamination of deep groundwater by the septic seepage appears to be unlikely.

8) Information on deep wells is inadequate to develop a reliable estimate of phosphate influx into the lakes.

9) The total annual PO_4-P loading from leaking septic tanks or direct discharges into the lakes ranges approximately from 100 kg to about 234.0 kg. The actual discharge is likely to be closer to the minimum value.

10) There is a need to coordinate and compile the activities of different agencies who collect various types of field data in the Qu'Appelle basin. This will help to develop a comprehensive approach for evolving a phosphate balance in the Fishing Lakes.

11) As the soil and terrain properties determine the efficiency of phosphate containment within a soil zone, an investigation of the soil and topographic characteristics should be carried out to delineate areas with desirable characteristics.

12) The attitude of the common property owner is largely influenced by lack of information about factors that contribute to the water quality deterioration, biased views or the fact that large sources are by their nature easily identified as culprits.

13) The information that is presently available on the phosphate influx from direct precipitation (rain and snow) on the lakes should be updated by more extensive studies. Recent studies in other parts of Canada have shown that this contribution may not be insignificant.

ACKNOWLEDGEMENT

Many individuals and agencies extended helpful assistance and co-operation during the course of the study. Special thanks are due to the following who made special efforts to provide the information needed.

1) Pantel Plumbing and Heating Ltd., Fort Qu'Appelle
2) Fort Septic Services, Fort Qu'Appelle
3) Qu'Appelle Implementation Office, Fort Qu'Appelle, particularly Mr. A.C. Schuster, director and Mrs. Linda Walker, Research Officer.
4) Department of Public Health, Regina., Mr. Gushalak, Senior Public Health Inspector, Regina and Mr. Bob Stone, Public Health Inspector, Fort Qu'Appelle
5) Department of Municipal Affairs, Regina
6) Department of the Environment, Water Quality Branch, Regina.

Mr. J.T. Jones, Senior Research Technologist, Engineering Division, Saskatchewan Research Council was responsible for the data acquisition and field operations and was assisted by Mssrs. R.E. Bouvier, and D. Didur. Mr. Harm Maathuis, Geohydrologist, helped in the preparation of auger-hole lithology and the collection of field data.

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APPENDIX A

APPENDIX B